

PROCEEDINGS OF THE I.R.E.

AND

WAVES AND ELECTRONS



John F. Garfield, Radiation Laboratory, M.I.T.

ANTENNA OF THE EIGHTH AIR FORCE MICROWAVE EARLY WARNING AT
GREY FRIARS, EAST ANGLIA, SHOWN AS IT WAS CONTROLLING THE
EIGHTH AIR FORCE FIGHTER PLANES ON THE DAY OF
THE DUTCH AIRBORNE INVASION

June, 1946

Volume 34

Number 6

PROCEEDINGS
OF THE I.R.E.

Pulse-Type Angular-Velocity
Modulation

Current Distribution for Broadside
Arrays

High-Impedance Cable

Locking Phenomena in Oscillators

Waves and Electrons
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The amazing wealth of accomplishments of science and technology during the recent decades, and the corresponding major opportunities for determined and effective thinkers in these fields are subjects of particular interest to radio-and-electronic engineers. There is accordingly presented to the membership the following guest editorial written by an eminent electronic engineer and pioneer, who is active in the research laboratory of the General Electric Company and is a Fellow of the Institute, a member of its Board of Directors, and a member of its Executive Committee.—*The Editor.*

There Is Always Room at the Top

W. C. WHITE

When in the late eighteen eighties Thomas Edison put into service the first large public-utility power station, the power supply was direct current, which of course is zero frequency. Although at the time it was a wonderful advance in engineering, it had severe limitations in regard to the area that could be served and its flexibility.

The advent of the alternating-current system, even at the low frequency of 25 cycles, gave rise to a great expansion of the central-station industry and the increase of frequency to 60 cycles brought on still further improvements. Meanwhile, other engineers in a different field were expanding knowledge on devices and circuits for frequencies in the range of hundreds to several thousands of cycles per second, and this was laying the foundation for our present universal telephone system.

Then, of course, came the early wireless engineers struggling to establish transatlantic and other long-distance contacts on a commercial basis at tens to hundreds of thousands of cycles per second.

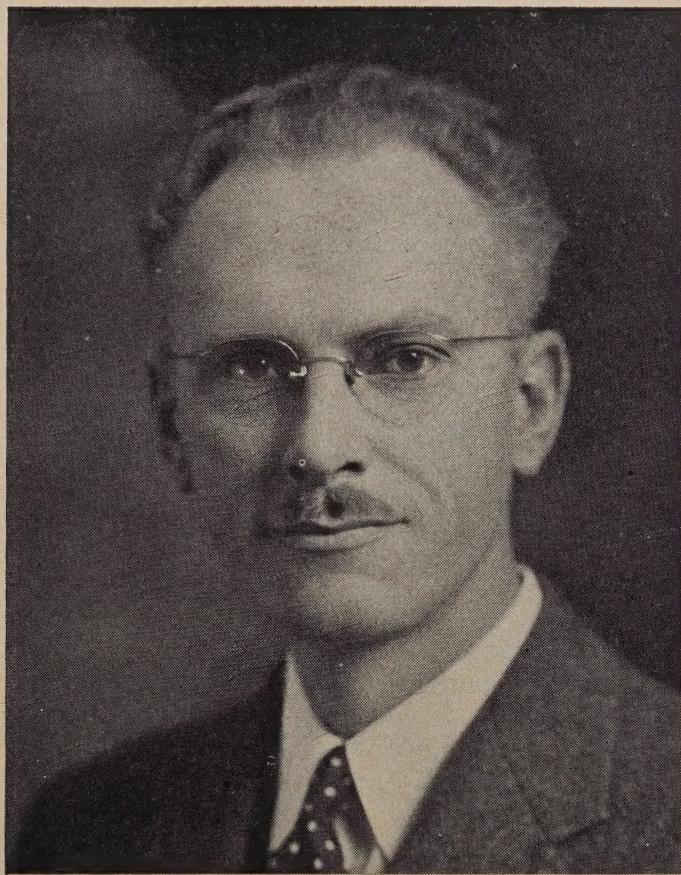
Following World War I, radio engineers provided the basis on which was established our present broadcast system at around a million-cycle frequency. Frequency-modulation broadcasting, the latest improvement in that field, is expected to expand greatly the number of both transmitters and receivers, and this is based on the use of still higher frequencies.

The point to notice is that every time a new and distinctly higher-frequency band has been opened up to use by new engineering knowledge a whole new industry has come into being, involving new capital investment, new public services, and employment to many additional thousands or even hundreds of thousands of persons.

Television is here with its utilization of frequencies of the order of a hundred-million cycles or even higher, and it constitutes one of the country's most promising postwar industries. Already new and improved tubes and techniques are being employed experimentally for frequencies severalfold higher than in use in present-day television. These developments are leading to the long-distance radio relaying of programs and the utilization of color.

Now today, as a result of developments during World War II, physicists and radio engineers have carried the advance still further and learned how to generate and handle frequencies of the order of billions of cycles.

In view of the past record, where each upward step in frequency has expanded greatly the field for some branch of electrical engineering, do we not have every reason to expect that this new knowledge will soon create its share of new business opportunities, employment, and benefits to our normal daily lives? Possibly there may be involved a whole new industry not now visualized.



Frank H. R. Pounsett

Chairman, Toronto Section, 1946

Frank H. R. Pounsett was born in London, England, September 12, 1904, and moved to Canada in 1910. He was active in amateur radio following World War I and a member of the Wireless Association of Ontario.

He received the B.A.Sc. degree in electrical engineering, communications, at the University of Toronto in 1928. From 1928 to 1934, he was a member of the radio engineering staff at the De Forest Radio Corporation in Toronto, and was responsible for design and development of complete broadcast receivers and associated equipment. In 1934, he became chief engineer of the radio division of the Stewart-Warner—Alemite Corporation, Belleville, Ontario, where he remained until 1940. In that year, Research Enterprises Limited, a Crown Company, was formed at Toronto to manufacture optical glass, optical instruments, and radar equipment for the United Nations Armed Forces. All radar equipment manufactured in Canada was assembled and shipped from this large plant. As chief engineer of

the radio division, Mr. Pounsett was responsible for the production-development and engineering of numerous types of radar equipment and accessories. On January 1, 1946, Mr. Pounsett was appointed chief engineer of the Stromberg-Carlson Company, Limited, at Toronto, where he is responsible for the design and engineering of broadcast receivers, amplifiers, sound systems, telephone, and other communications equipment, for Stromberg-Carlson in Canada.

Mr. Pounsett joined the Institute of Radio Engineers as an Associate in 1926 and was transferred to Senior Member grade in 1944. He is at present chairman of Toronto Section, and a member of the executive committee of the Canadian Council of the I.R.E. He is also a member of the Association of Professional Engineers of Ontario and of the Royal Canadian Institute. He has served on many committees of the Engineering Division of the RMA in Canada, and of the Canadian Electrical Code.

A New Angular-Velocity-Modulation System Employing Pulse Techniques*

JAMES F. GORDON†, ASSOCIATE, I.R.E.

Summary—A method is described wherein crystal-controlled phase- or frequency-modulated carriers may be produced having relatively large deviation angles.

A circuit is described wherein the harmonic distortion during modulation is held to a low value.

An experimental transmitter is shown utilizing one form of the system. Also shown are oscillograms of the voltages occurring in various portions of the modulation system.

INTRODUCTION

IT HAS been generally recognized that crystal-controlled sources for angular velocity modulation are desirable because of the simplicity of frequency stabilization. It has been recognized further that crystal-controlled sources having large deviation characteristics are even more desirable since the number of multiplier stages between the crystal oscillator and the antenna stage may be reduced. Many systems, though capable of providing relatively large angular deviations during modulation, are useful only at the smaller deviation angles because of the excessive distortion encountered at the larger deviations.

The system here described provides a means of obtaining relatively large deviation angles which may be used to produce phase- or frequency-modulated radio-frequency carriers having low distortion.

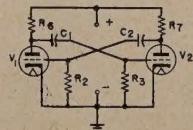


Fig. 1—The multivibrator circuit of Abraham and Bloch

Consider the well-known multivibrator circuit of Fig. 1. The ideal output of such a circuit where both halves are electrically symmetrical is a square wave

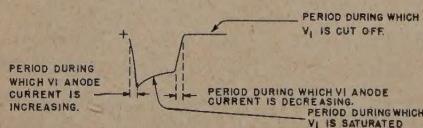


Fig. 2—The actual multivibrator output from either anode will more closely resemble this wave form during the conducting period, rather than the ideal square wave.

with the conducting periods equally divided between the two tubes. In actual practice it is not possible to accomplish the ideal, and the anode-voltage conditions for either tube during the conducting period will more closely follow the conditions shown in Fig. 2.

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† Bendix Radio Division, Baltimore, Maryland.

If the time constants of the circuit of Fig. 1 are changed to give V_2 a longer conducting period, the ideal voltage conditions for V_1 anode would appear as in Fig. 3. If the time constants were changed to give V_1 the longer conducting period, the V_1 anode conditions would appear as in Fig. 4.

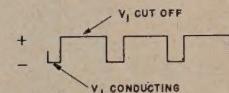


Fig. 3—The ideal voltage conditions for V_1 anode where V_2 has the longer conducting period.

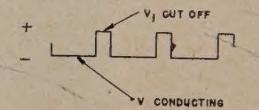


Fig. 4—The ideal voltage conditions for V_1 anode where V_1 has the longer conducting period.

From this it is evident that the conducting time may be made to favor either V_1 or V_2 by changing the time constants of the circuit.

If the time constants of the two circuits are left identical and the negative potential of one of the tube grids is increased, as in Fig. 5, with respect to the other grid, the grid with the highest negative potential will go negative sooner and stay negative longer than the other.

The result is that V_1 has a longer conducting period than V_2 . If the V_2 negative grid voltage was to be reduced to a lower negative value than that of V_1 , then V_2 would have the longer conducting period.

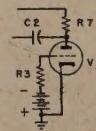


Fig. 5—The conducting time of either of the tubes in the two-tube multivibrator circuit may be influenced by changing the grid voltages.

From the foregoing it is evident that the time at which V_1 or V_2 changes from a conducting to a nonconducting condition or vice versa may be controlled by the amplitude of the grid voltage on either tube with respect to the grid voltage of the other.

APPLYING AN AUDIO VOLTAGE TO THE MULTIVIBRATOR

If a sine voltage is applied to either the V_1 or V_2 grid, the conducting time of the tubes would vary in accordance with this voltage. Examination of the V_1 anode conditions shows that the switch-over period varies from minimum to maximum as shown in Fig. 6,

from the instant the V_1 anode goes positive. The minimum time, as controlled by the positive peak of the audio cycle, will be as small as the switch-over time, and the maximum time as controlled by the negative peak of the audio cycle will be within the length of the switch-over time of being the major portion of a cycle later.

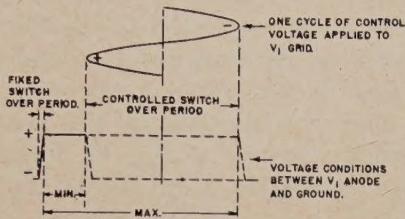


Fig. 6—The relationship between the positive and negative peaks of the audio modulating voltage and the minimum and maximum excursion of the switch-over period of the multivibrator.

It is theoretically possible to obtain nearly a zero- to 360-degree variation of the switch-over time in this manner, or a deviation of almost 180 degrees either side of the center position. In actual practice, this great a deviation is not completely accomplished. A phase deviation of the switch-over period which may be controlled by the amplitude of a modulating voltage is thus realized.

If the output voltage from V_1 anode is differentiated, a series of positive and negative pips or pulses of very short duration results, as in Fig. 7.

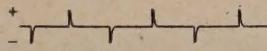


Fig. 7—Differentiated output of the ideal multivibrator where conducting periods are equal.

The positive pips will remain stationary during the application of a modulating voltage to the grid of V_2 . (See Fig. 18(h).) The negative pips will change position.

By clipping the positive pulses and inverting and amplifying the negative pulses, a series of positive pulses which are suitable to drive a class C amplifier is obtained (see Fig. 18(f)). (This is a form of pulse-position modulation which forms the basis of a forthcoming paper).

The relationship between the position of the negative pips from the differentiated V_1 anode voltage and the modulating voltage is shown in Fig. 8.

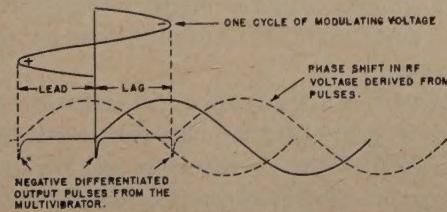


Fig. 8—The relationship between the multivibrator modulating voltage, the differentiated multivibrator output pips, and the resultant radio-frequency voltage.

By tuning the plate circuit of the class-C amplifier to a frequency which is comparable to the repetition rate of the grid pulses driving it, a radio-frequency volt-

age is obtained which may be controlled in phase by the phase variations of the switch-over time in the multivibrator circuit.

There are several factors which enter into the actual application of this circuit to radio communications, as follows:

(1) The multivibrator is not a sufficiently stable oscillator in itself to provide adequate frequency control for transmitting equipment. The multivibrator becomes even more unstable if the previously described modulation is used.

(2) The multivibrator must be capable of operating at frequencies of at least 100 kilocycles and higher with good square wave form.

(3) Accurate synchronizing of the multivibrator from a crystal-controlled source requires that the crystal-oscillator output be preferably in the form of a sharp pulse. For the circuit described here this pulse should be negative in polarity.

(4) Circuit reactances should be such as not to make the multivibrator phase deviation nonlinear with respect to the amplitude or frequency of the modulating voltage.

CONTROLLING THE MULTIVIBRATOR FREQUENCY

A crystal oscillator may be used as the multivibrator control by applying its output to an amplifier (Fig. 9)

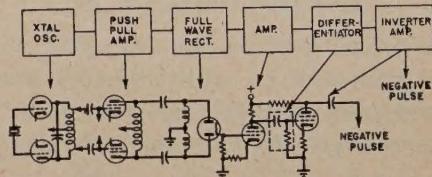


Fig. 9—Block diagram and schematic of crystal-oscillator and rectifier circuit for controlling the multivibrator.

which feeds a full-wave rectifier. The rectifier output will consist of positive pulses at twice the oscillator frequency (see Fig. 10).

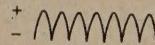


Fig. 10—Typical full-wave rectifier output.

These may be amplified and differentiated and the negative pulses eventually derived may be used to synchronize the multivibrator.

Another method is to synchronize a blocking oscillator with a crystal and use the blocking oscillator output to synchronize the multivibrator.

The first method requires more tubes and power, while the second requires fewer tubes, is simpler, and has lower power requirements (see Figs. 9 and 11).

In the first case, any asymmetry in the rectifier output is likely to cause unwanted phase variations which will present themselves as noise or undesired sidebands of the final transmitter output frequency. Careful balancing of the rectifier plate transformer will tend to reduce this type of trouble.

In the second method, there are two possibilities for

noise and attendant instability at the final output frequency. The first is that the blocking oscillator may not trigger off at exactly the same time for each pulse, and the second is that the multivibrator might react on the blocking oscillator during modulation to create instability.

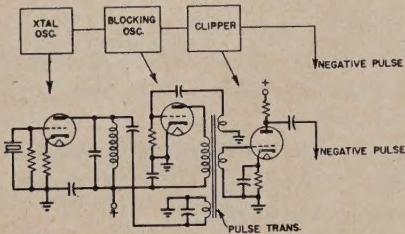


Fig. 11—Block diagram of synchronized blocking oscillator for driving the multivibrator.

A simple way to synchronize the blocking oscillator is to feed the synchronizing voltage into an extra winding of the pulse transformer. In almost every case the blocking oscillator will trigger off on the steepest portion of the synchronizing wave (see Fig. 18(a)). By using a strong blocking-oscillator pulse and coupling it loosely to the multivibrator, there is no reaction on the blocking oscillator due to multivibrator modulation.

OPERATING THE MULTIVIBRATOR AT RADIO FREQUENCIES

High-mu triodes such as the 7A4, XXL, or 6J5 will operate satisfactorily as multivibrators between 100 and 200 kilocycles with fair wave form. A type 7F8 will operate satisfactorily to at least 400 kilocycles.

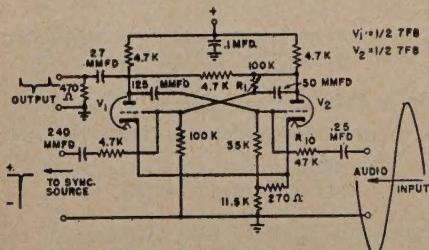


Fig. 12—A high-frequency two-tube multivibrator circuit which will operate between 200 and 400 kilocycles, and which may be modulated to produce negative phase-modulated pulses.

The circuit of Fig. 12 is a modified form of the simple two-tube multivibrator described in the introduction. Here the synchronizing voltage is fed to the grid of V_1 , and the audio modulating voltage to the grid of V_2 . The output is taken from the V_1 plate.

It is necessary to keep the plate load resistances low enough to provide fairly good square wave form at the multivibrator frequency and at the same time have sufficient multivibrator output. A voltage of 5 volts or more peak from the multivibrator is sufficient for satisfactory operation.

Close assembly of the components around the tube sockets is desirable to minimize stray coupling.

The multivibrator is easily disturbed by stray fields, and for this reason the circuit should be well shielded.

AUDIO-FREQUENCY LOSSES IN THE MULTIVIBRATOR

There are no appreciable audio-frequency losses in the multivibrator. Note that the relatively high resistance to ground from the grid of V_2 will not unduly load a 500-ohm input to it through the decoupling resistor R_{10} (see Fig. 12). In a like manner, the input circuit is prevented from reacting on the multivibrator. The degeneration accomplished across the V_2 cathode resistor is desirable. By using a suitable radio-frequency choke in place of R_{10} , audio losses may be further minimized. The root-mean-square sine-wave input at the audio input terminals of Fig. 12, to accomplish a phase swing of 90 degrees, is approximately 15 volts.

THE CYCLE OF OPERATION

A negative pulse of 5 to 10 volts amplitude and about a fifth of a microsecond duration (Fig. 18(b)) drives V_1 grid negative (Fig. 18(c)) causing V_1 anode to go positive, which drives V_2 grid positive firing V_2 , which maintains V_1 grid negative for a period depending upon the circuit time constants and the grid biases. The V_1 grid bias eventually leaks off and V_1 grid goes positive, firing V_1 . The action is now reversed and V_1 remains conducting, due to its positive grid, until another pulse arrives to trigger V_1 grid negative.

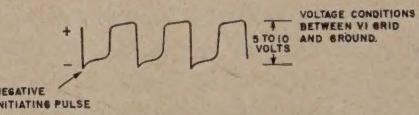


Fig. 13—A sharp negative synchronizing pulse initiates each new multivibrator cycle.

The circuit is adjusted by proper choice of common cathode resistance such that the multivibrator will just oscillate of its own accord. The time constants are so chosen that the rate of self-oscillation is somewhat lower than the required rate during synchronized operation. By so adjusting the circuit, the initiating negative pulse to the V_1 grid always controls the beginning of a new multivibrator cycle (see Fig. 13 and Fig. 18(c)).

The circuit may be adjusted as a "flip-flop" circuit entirely, but the method of just biasing the circuit to sustain self-oscillation requires a less-powerful synchronizing pulse. If the multivibrator constants are too low, the circuit may divide frequency; or, on the other hand, if they are too high, multiplication may result. Both conditions are undesirable for proper operation of the circuit.

Since the method of coupling the negative initiating pulse to the V_1 grid will affect the time constants of the circuit, the multivibrator must be set up and tested with this part of the synchronizing circuit attached. A series resistance in this part of the circuit is helpful in reducing capacitive reactance between the blocking oscillator and the multivibrator.

By making R_1 variable, the switch-over time may be adjusted to occur in the center of the multivibrator cycle. This should always be the resting point of the

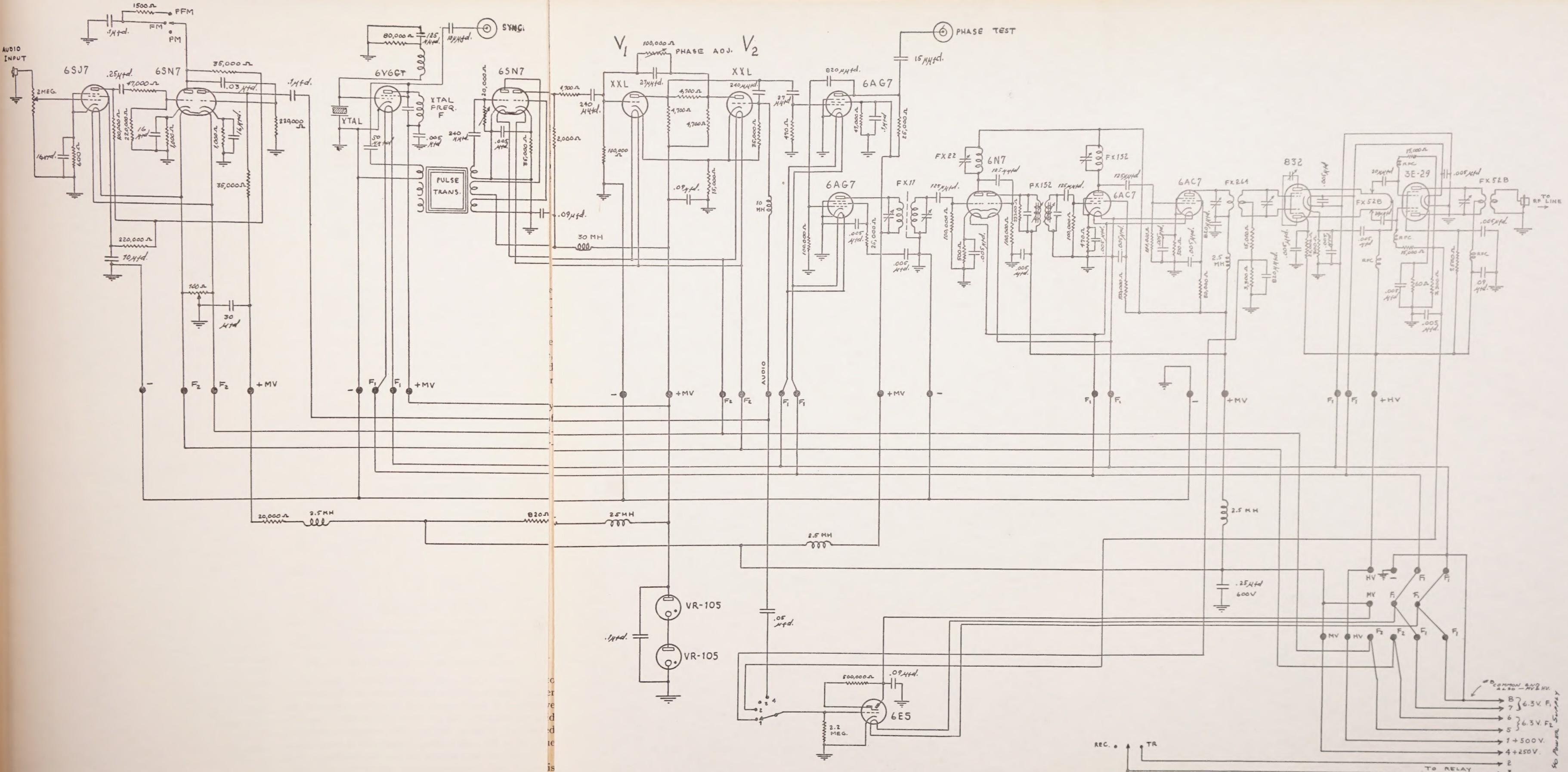


Fig. 15—Experimental very-high-frequency transmitter for angular-velocity modulation.

multivibrator switch-over period in the absence of modulation. The values of the circuit in Fig. 12 have been arrived at experimentally and will vary somewhat with the arrangement of components and wiring, circuit loading, etc.

Since, during a modulation cycle, if anode saturation or grid cutoff of V_2 took place during the multivibrator switch-over period (i.e., during the time V_2 grid was going from negative to positive), this switch-over time would be altered. For a part of the time during a modulation cycle V_2 is cut off, and the remainder of the time it is conducting near saturation. If grid current during the part of the multivibrator cycle in which V_2 is conducting is high, then large grid current will flow in the V_2 grid resistor, creating audio distortion which will be largely second harmonic since it is effectively occurring during only the positive half of the modulating cycle. To reduce distortion from this source, the V_2 grid may be returned to a tap on the cathode resistor as shown in Fig. 12.

Distortion from this source does not have as great an effect as might at first be supposed. The period during which this distortion will be effective is the time during which V_2 goes from saturation to cutoff. The relationship between a positive pulse which is originally derived from the output of V_1 anode and the period during which V_2 goes from saturation to cutoff is shown in Fig. 14.



Fig. 14—The relationship between a positive pulse derived from the first multivibrator-tube anode and the period during which the second tube goes from saturation to cutoff.

The positive-pulse peaks are effective in driving the multiplier chain and these peaks occur near the cutoff point of V_2 , which is the point where distortion of the type just mentioned will be negligible. In the experimental transmitter of Fig. 15 it was not found necessary to use the cathode resistance in order to obtain good intelligence.

THE EXPERIMENTAL TRANSMITTER

An experimental transmitter was set up to test the system under actual application. Two XXL-type tubes were used experimentally and performed satisfactorily as multivibrators at 200 kilocycles. The synchronizing circuit of Fig. 11 was used. A 6AG7 tube inverts and clips the differentiated output of the first multivibrator tube so that in its plate circuit occur 200,000 1-microsecond pulses per second (see Fig. 18(f)). These pulses drive the grid of a 6AG7 first multiplier. A total multiplication of 528 times the crystal frequency is accomplished to give an output frequency of 105.6 megacycles. Voltage-regulator tubes maintain the multivibrator anode supply at 210 volts for stability.

A three-stage audio channel was provided with switching to give direct phase modulation, frequency modulation, or pre-emphasized frequency modulation. The effect of modulation throughout the multivibrator circuit is shown in Fig. 18(g), (h), (i), and (j).

The circuit of Fig. 16 is more desirable as a source of angular velocity modulation than that of Fig. 12. The larger part of the distortion to be encountered during modulation stems from the fact that the discharge curve of a capacitor is exponential rather than linear. For this reason, the linearity of modulation depends largely upon how narrow a section of this exponential curve can be

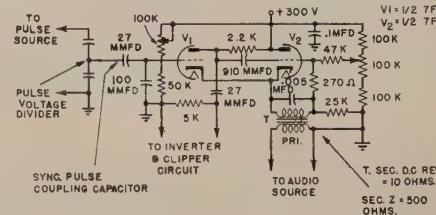


Fig. 16—A practical multivibrator circuit for 200- to 400-kilocycle operation which may be modulated by an audio voltage to produce angular-velocity-modulated negative pulses, the instantaneous phase angles of which follow faithfully the modulating-voltage conditions over relatively large deviations.

utilized for maximum phase swing. It is desirable to use as large a coupling capacitance to the V_1 grid as possible, and as low a grid resistance as will still permit good operation. Separate bias adjustments were provided for both V_1 and V_2 grids for optimum adjustment.

This circuit functions fundamentally as the previously described circuit with the exception that the anode of V_2 connects directly to the positive bus such that multivibrator coupling to V_1 is by means of the cathode circuit only.

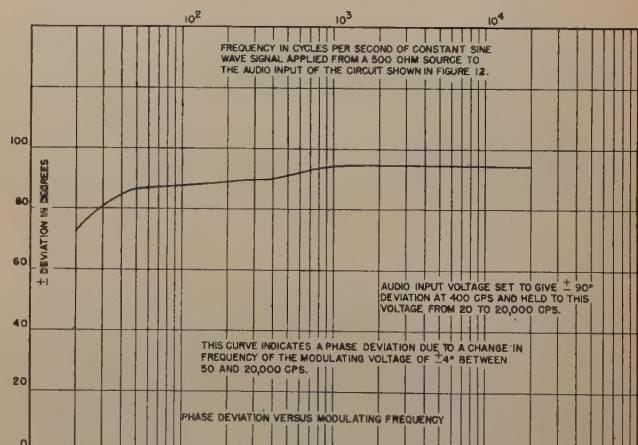


Fig. 17—Phase deviation versus modulating frequency.

Too high a synchronizing pulse has a tendency to feed through the multivibrator and occasionally trigger the multiplier chain at the wrong time. A capacitive voltage divider at the input to the synchronized grid provides a means of reducing this pulse to the desired value, which is just slightly greater than the peak value of the multivibrator output voltage (see Fig. 18(c)).

Like the previously described circuit, this circuit is

adjusted to be just barely free running at a frequency somewhat lower than the operating frequency.

A root-mean-square voltage of 1 volt across the secondary of the modulation transformer will create a phase swing of approximately 180 degrees. This places very low requirements on the audio circuits.

NOISE MEASUREMENTS

Using a frequency-modulation receiver tuned to the

transmitter output frequency, an unmodulated signal from a standard signal generator was used to drive fully the limiters of the receiver. The noise present on this signal was measured as 0.0022 volt root-mean-square. The transmitter of Fig. 15 was adjusted then to replace the standard generator signal and the noise voltage present under the same power input to the receiver was 0.0032 volt. Most of this appeared as random noise throughout the audio spectrum. These measurements

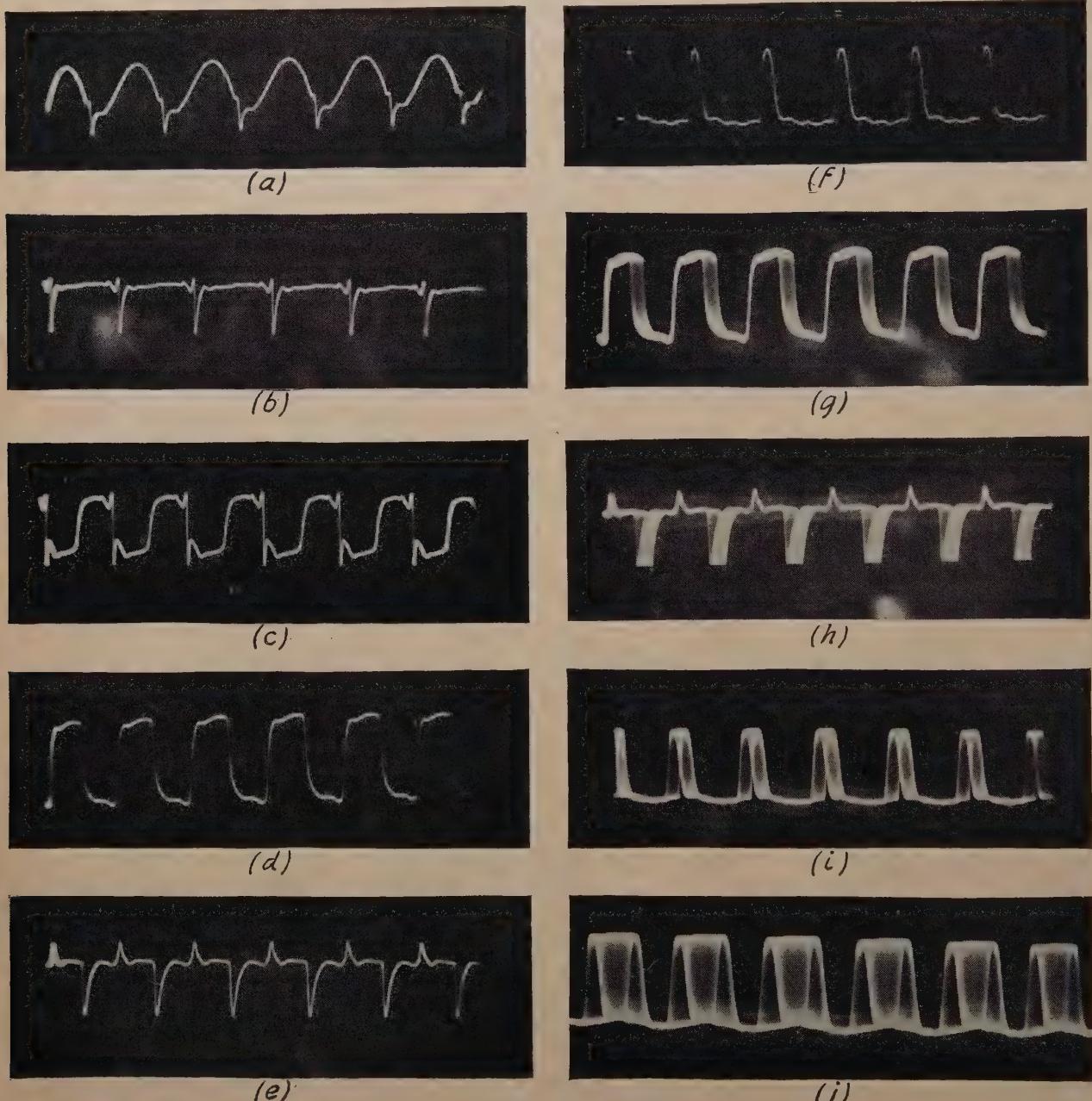


Fig. 18—Oscillograms taken from the transmitter shown in Fig. 15.

- (a) Relationship between crystal-oscillator output and blocking-oscillator output pulse.
- (b) Blocking-oscillator output after clipping. This pulse is applied to V_1 grid.
- (c) Conditions on V_1 grid showing how the blocking-oscillator pulse initiates the multivibrator cycle.
- (d) Conditions on V_1 anode.
- (e) The differentiated output from V_1 anode as it appears on the first 6AG7 grid.
- (f) The output of the first 6AG7. This positive pulse drives the first multiplier tube.
- (g) Same as Fig. 18(d) but with modulation applied.
- (h) Same as Fig. 18(e) but with modulation applied.
- (i) Same as Fig. 18(f) but with modulation applied.
- (j) Same as Fig. 18(f) but with wide modulation swing of approximately 200 degrees.

were made with the audio modulators in the transmitter disconnected. Applying 400-cycle modulation to the transmitter and keeping the receiver input at the same level resulted in approximately 65 decibels increase in output from 0.0032 volt while maintaining a 150-kilohertz swing at the transmitter output frequency. Since this noise is evenly distributed, these conditions remained constant throughout the usable audio spectrum.

PHASE DEVIATION VERSUS MODULATING FREQUENCY

The modulating voltage concerned in this measurement was applied directly to the modulator input circuit of the transmitter multivibrator (see Fig. 15). A low enough audio-oscillator output impedance was used to reduce any tendencies toward high-frequency attenuation. The audio output of the signal generator was set at a level to provide a 180-degree multivibrator swing at 400 cycles per second. The input voltage was then held constant and the frequency was varied between 20 and 20,000 cycles per second. The resultant phase deviation due to a change in modulating-voltage frequency, as shown in Fig. 17, was taken from measurements on an expanded oscilloscope time base. The circuit of Fig. 16 is linear throughout the range within 2 degrees, and is more desirable from this standpoint than the circuit of Fig. 12.

Fig. 18 includes oscillograms of the multivibrator grid and plate conditions. Fig. 18(c) particularly shows the relationship between the synchronizing pulse amplitude and the amplitude of the multivibrator grid voltage.

AMPLITUDE MODULATION IN MULTIVIBRATOR OUTPUT

The amplitude modulation present under all conditions in the multivibrator output is insignificant. Any appreciable amplitude variation would tend to create distortion during modulation.

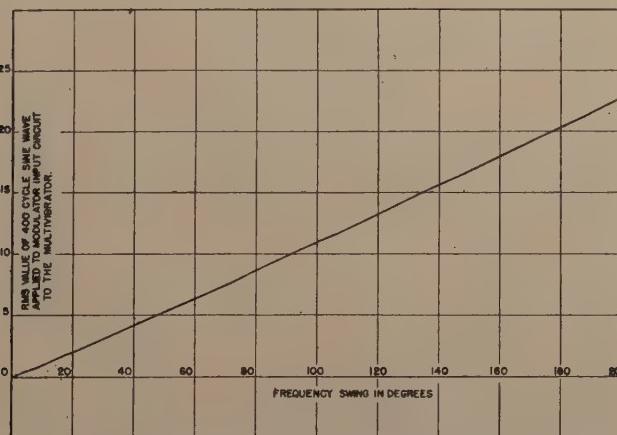


Fig. 19—Measured swing in degrees versus the 400-cycle modulating voltage required to produce the swing of the multivibrator output used in the transmitter of Fig. 15.

LINEARITY OF MODULATION

The curve of Fig. 19 indicates the measured phase swing versus modulator-input volts at 400 cycles per

second. It was accomplished in the following manner.

The oscilloscope was synchronized to show the radio-frequency wave of one of the multiplier stages. Modulation was then applied slowly to the transmitter. Each time a 360-degree swing at the multiplied frequency was indicated by an overlapping of the screen tracings, the voltage required to give this swing was tabulated.

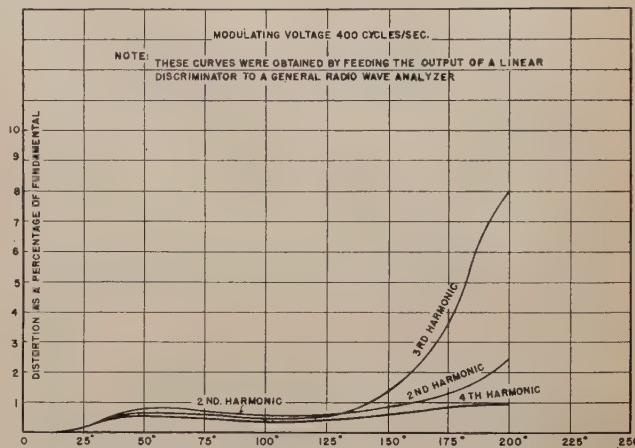


Fig. 20—The measured harmonic distortion of the circuit of Fig. 16 showing distortion percentage versus swing in degrees for a modulating frequency of 400 cycles. See Fig. 21 for test setup used in making measurements.

The curve of Fig. 19 was drawn from this information. Close examination will show that this is not a straight line but appears slightly exponential. This curve should not be used as a true indication of harmonic distortion, since the method used has some tendency to average the upper and lower phase swings. For measured distortion of the circuit of Fig. 16, see Fig. 20.

HARMONIC DISTORTION OF THE MODULATED MULTIVIBRATOR OUTPUT

In order to determine the distortion present in the modulated multivibrator output signal, the test setup shown in Fig. 21 was used.

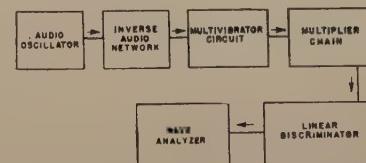


Fig. 21—Test setup for distortion measurements on the system.

An audio oscillator having a total harmonic distortion less than 0.1 per cent at 400 cycles was used to modulate the multivibrator of Fig. 16, the output of which was multiplied approximately one hundred times in a heavily damped multiplier chain, and fed to a linear discriminator.

This multiplication of 100 resulted in a maximum bandwidth at the discriminator of approximately 125 kilocycles for a multivibrator phase swing of 180 degrees. This was well within the measured limits of the linear characteristics of the discriminator used.

The discriminator output was fed directly to a General Radio wave analyzer. The distortion due to the audio oscillator, multiplier chain, and discriminator under these conditions is small, and the curves of Fig. 20 accurately indicate the measured harmonic distortion up to the fourth harmonic for a multivibrator swing of 200 degrees.

Due to the conditions set forth previously, the circuit of Fig. 12 has somewhat more distortion present than is shown here for the circuit of Fig. 16.

CONCLUSION

The modulated multivibrator, using pulse synchronization and pulse techniques to develop sine-wave output voltages which can be used to provide phase or frequency modulation of radio-frequency carriers, has applications in communications and broadcast transmission.

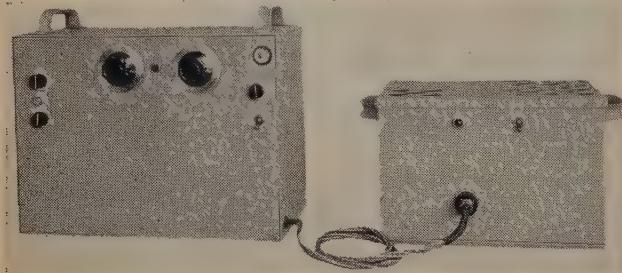


Fig. 22—Experimental transmitter (left) and power supply (right) used in the tests. The final power-amplifier input and output adjustments, plus the audio input circuit, are on the front panel

Several features characterize the system:

- (1) no amplitude modulation due to phase modulation;
- (2) phase swing versus modulation frequency is constant;
- (3) a relatively small modulating voltage is required;
- (4) relatively large phase swings may be accomplished with low distortion;
- (5) frequency stabilization by means of crystal-controlled pulses;
- (6) pulse initiation of the multiplier chain.

Three views of an experimental transmitter which was built around the system described are shown in

Figs. 22, 23, and 24. The schematic of this transmitter is shown in Fig. 15.

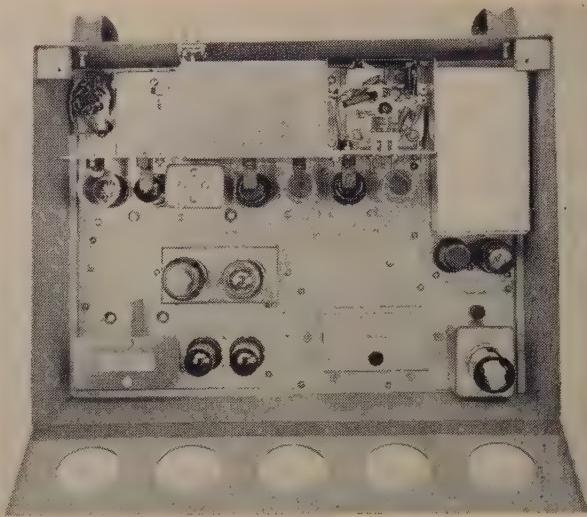


Fig. 23—Rear view of the transmitter with the panel open. The blocking oscillator is at the extreme lower right, while the two multivibrator tubes are to the left under the cover marked "phase adj."

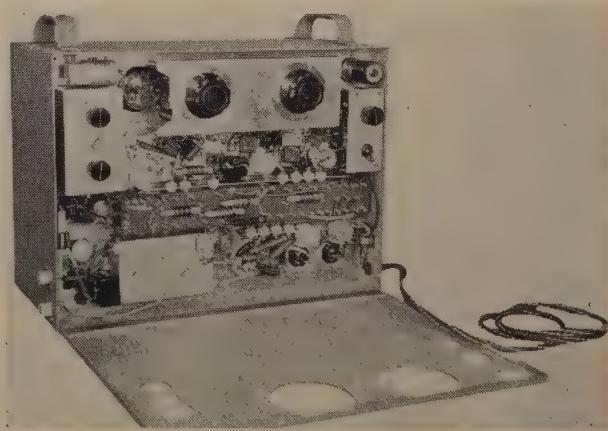


Fig. 24—Front view of the experimental transmitter with front panel open. The two-tube multivibrator circuit is housed within the shield at the lower left.

ACKNOWLEDGMENT

The author wishes to express his appreciation for the comments and suggestions made by A. C. Omberg and Dr. Harold Goldberg during the preparation of the original paper.

A Current Distribution for Broadside Arrays Which Optimizes the Relationship Between Beam Width and Side-Lobe Level*

C. L. DOLPH†

Summary—A one-parameter family of current distributions is derived for symmetric broadside arrays of equally spaced point sources energized in phase. For each value of the parameter, the corresponding current distribution gives rise to a pattern in which (1) all the side lobes are at the same level; and (2) the beam width to the first null is a minimum for all patterns arising from symmetric distributions of in-phase currents none of whose side lobes exceeds that level.

Design curves relating the value of the parameter to side-lobe level as well as the relative current values expressed as a function of side-lobe level are given for the cases of 8-, 12-, 16-, 20-, and 24-element linear arrays.

INTRODUCTION

FROM THE practical viewpoint, several things are desired of broadside antenna arrays. The beam should be as narrow as possible, the power gain a maximum, and the side lobes, if any, at a low level.

It is often a difficult matter to reconcile these demands. To illustrate, the gain may be made a maximum by feeding all of the point sources currents of equal magnitude and phase. Unfortunately, although it is true that this current distribution results in a narrow beam width, it also results in high side lobes of the order of 12 decibels down on the main lobe. In many applications it is more important to sacrifice some gain and beam width in order to achieve low-level side lobes. Several schemes have been suggested as a means of accomplishing this.

In particular, John Stone Stone¹ suggested that the point sources in an array of N elements be fed currents in phase with amplitudes proportional to the coefficients of a, b in the expansion $(a+b)^{N-1}$. The use of this so-called binomial expansion results in the total elimination of side lobes for spacings between the elements less than one-half wavelength but is in general impractical because of the increased beam width, loss of gain, and large current ratios demanded for large arrays.

S. A. Schelkunoff,^{2,3} utilizing for the first time a correspondence between the nulls of the pattern and the roots of complex polynomials on the unit circle in the complex plane, was able to devise another scheme which did away, in part, with the above difficulties. By suitably spacing the roots of these polynomials on that por-

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† Formerly, Combined Research Group, Naval Research Laboratory, Washington, D. C.; now, Bell Telephone Laboratories, Murray Hill, N. J.

¹ John Stone Stone, United States Patents No. 1,643,323 and No. 1,715,433.

² S. A. Schelkunoff, "A mathematical theory of arrays," *Bell Sys. Tech. Jour.*, vol. 22, pp. 80-107; January, 1943.

³ S. A. Schelkunoff, United States Patent No. 2,286,839.

tion of the unit circle traced out, he was able to derive many different types of pattern variation. In particular, by spacing these roots equally on the appropriate arc of the unit circle, he was always able to obtain an improvement in the side-lobe level over that of the uniform case for spacings less than one wavelength. In this case, an algebraic identity led to formulas from which the current amplitudes and phases could be calculated. Since his treatment was carried out in the complex domain, it possessed the added advantage that it applied to both end-fire as well as broadside arrays. Although this method offers many advantages, it does not constitute a complete answer to this problem, since in certain applications the resulting improvement is inadequate.

This paper presents a third means of improving the pattern of linear arrays for the special broadside case in which the elements are fed in phase and are symmetrically arranged about the center of the array. The resultant current distribution across the array is based upon properties of the Tchebyscheff polynomials and offers, from the design standpoint, much greater control of the pattern. In particular, it possesses the following advantages:

(1) The current distribution can be calculated after either the side-lobe level or the position of the first null is specified.

(2) The current distribution is optimum in the sense that (a) if the side-lobe level is specified, the beam width is as narrow as possible (i.e., the number of degrees from the center of the beam to the first null is minimized); or (b) if the first null is specified, the side-lobe level is minimized.

(3) After either the side-lobe level or the position of the first null is specified, the position of the other nulls and of the side lobes can be found by simple calculation.

(4) All lobes other than the main beam and any other lobe arising from an in-phase condition of the same type as the main beam are at the same level.

(5) Detailed calculation of the pattern is unnecessary since the character of the pattern is completely known from the above properties.

GENERAL PATTERN CONSIDERATIONS

The discussion of linear broadside symmetric arrays of equally spaced point sources differs slightly in detail depending upon whether the arrays contain $2N$ or $(2N+1)$ elements. In the first case there is no radiating element at the center 0 of the array while in the second

Theere is. These two different types with the appor-
erale values of I_n corresponding to the various point
ources are shown in Figs. 1 and 2, respectively. In
either case, let the center of the array 0 be taken as the
phase reference point, let d denote the constant spacing

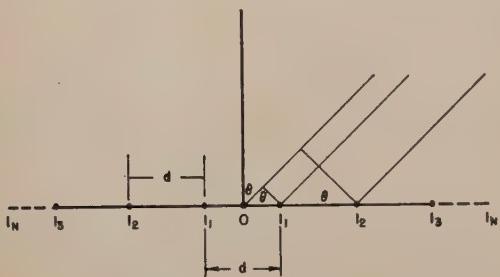


Fig. 1—Reference system for an array of $2N$ point sources.

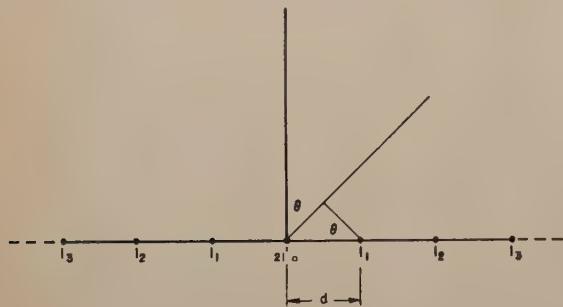


Fig. 2—Reference system for an array of $(2N+1)$ point sources.

between the point sources, let θ denote the angle be-
tween the direction of the field to distant point P and the
normal to the array. Let I_n be proportional to the
current fed into the point source located at a distance
 $(2n-1)d/2$ for Fig. 1 and at a distance of (nd) for Fig. 2.
Let $2I_0$ denote the current fed into the center point
source in Fig. 2. Then the field pattern of arrays of the
type of Fig. 1 is well known to be proportional to

$$|E_{2N}(\theta)| = \left| \sum_{k=0}^{N-1} I_k \cos \left\{ \frac{(2k+1)}{2} \left(\frac{2\pi d}{\lambda} \right) \sin \theta \right\} \right|. \quad (1)$$

Similarly, the field pattern of arrays of the type of Fig. 2
is proportional to

$$|E_{2N+1}(\theta)| = \left| \sum_{k=0}^N I_k \cos \left\{ k \left(\frac{2\pi d}{\lambda} \right) \sin \theta \right\} \right|. \quad (2)$$

It must be emphasized again that (1) and (2) are valid
only if all the currents are in phase along the array. Introduc-
ing the variable

$$u = \frac{d\pi}{\lambda} \sin \theta, \quad (3)$$

(1) and (2) become respectively

$$|F_{2N}(u)| = \left| \sum_{k=0}^{N-1} I_k \cos (2k+1)u \right| \quad (4)$$

and

$$|F_{2N+1}(u)| = \left| \sum_{k=0}^N I_k \cos (2ku) \right|. \quad (5)$$

In either case, the discussion of (4) and (5) can be
reduced to the consideration of polynomials of a real
variable $x=\cos u$ on the real interval $-1 \leq x \leq 1$. To
obtain the polynomial form, use is made of the fact that

$$e^{inu} = (\cos nu + i \sin nu) = (\cos u + i \sin u)^n$$

from which it follows that

$$\begin{aligned} \cos nu &= \cos^n u - \binom{n}{2} \cos^{n-2} u \sin^2 u \\ &\quad + \binom{n}{4} \cos^{n-4} u \sin^4 u + \dots \end{aligned} \quad (6)$$

where

$$\binom{n}{k} = \frac{n!}{k!(n-k)!}.$$

If $\sin^2 u$ is replaced by $(1-\cos^2 u)$ it is apparent that
 $\cos nu$ is a polynomial of degree n in $x=\cos u$. It therefore
follows that (4) and (5) are polynomials of degree
 $2N-1$ and $2N$ in x respectively, since they are merely
sums of cosine polynomials. In fact, (4) is of the form
 $xP_{N-1}(x)^2$ where P_{N-1} is a polynomial of degree $(N-1)$
and (5) is of the form $Q_N(x^2)$ where Q_N is a polynomial of
degree N .

Before obtaining explicit formulas for (4) and (5) in
polynomial form, it is interesting to note a few funda-
mental properties which are consequences of this type
of representation. The variable u is a universal parame-
ter, the range of which is determined by the d/λ ratio.
That is, if d/λ equals one, then the range of the variable
 u is clearly from $0 \leq u \leq \pi$. On the other hand, if d/λ is
one half, then the range of u is $0 \leq u \leq \pi/2$. Since $\cos u$
in the range $0 \leq u \leq \pi/2$ is the negative of $\cos(\pi-u)$ in
the range $\pi/2 \leq u \leq \pi$, it is clear that it is sufficient to
compute either (4) or (5) in the range $0 \leq u \leq \pi/2$ and
to use the recursion formula

$$|F(u)| = |F(\pi-u)| \quad (7)$$

corresponding to (4) and (5) respectively in order to
obtain the pattern as a function of u over the range
 $0 \leq u \leq \pi$. Similar formulas are obvious if d/λ exceeds
one. However, the range $0 \leq u \leq \pi/2$ corresponds to
half-wave spacing while the range $0 \leq u \leq \pi$ corresponds
to full-wave spacing. Since a change in frequency is
equivalent to a change in spacing, it follows that dif-
ferent portions of the fundamental pattern arising from
the range $0 \leq u \leq \pi/2$ occur as the frequency is
changed. In particular, it becomes apparent that a large
lobe equal to the main beam will arise at $\theta=90$ degrees
for wavelength spacing. Since for wavelength spacing,
 $u=\pi/2$ corresponds to $\theta=30$ degrees while $u=\pi$ cor-
responds to $\theta=90$ degrees, the fundamental pattern of
 θ occurs first in the 0- to 30-degree range and is then
repeated in reverse order in the 30- to 90-degree range
on θ giving rise to a lobe at 90 degrees roughly twice as
broad as (although equal in magnitude to) the main
beam. Since the only way to reduce this 90-degree lobe
is by the use of highly directive elements, it is in general

difficult to use spacing between the elements approaching one wavelength.

The introduction of the variable u makes clear the behavior of a broadside linear array over a band of frequencies provided that the current distribution remains unaltered as the frequency is shifted, a condition usually aimed at in design. That is, the portion of the fundamental pattern or multiples of it occurring in the range $0 \leq u \leq \pi/2$ merely changes as the frequency is shifted. In particular, if it is desired to calculate the performance of an array satisfying these conditions over a band of frequencies, it is only necessary to perform the calculations in terms of u over the basic range $0 \leq u \leq (\pi/2)$. The recursion formula (7), or others similar to it for values of d/λ greater than one, are then sufficient to give the pattern as a function of u corresponding to the d/λ ratio at the high end of the frequency band. Then it is only necessary to draw up a series of plots of (3) for the various d/λ ratios represented by the desired frequencies in the band and use this with the appropriate portion of the pattern as a function of u for the high end in order to obtain the complete pattern over the band.

In order to obtain explicitly polynomial representations in terms of $x = \cos u$ for (4) and (5), it is first necessary to verify that (6) implies that

$$\cos(2n+1)u = \sum_{m=0}^n A_{2m+1}^{2n+1} x^{2m+1} \quad (8)$$

where

$$A_{2m+1}^{2n+1} = (-1)^{n-m} \sum_{p=n-m}^n \binom{p}{p-n+m} \binom{2n+1}{2p} \quad (9)$$

and that

$$\cos 2nu = \sum_{m=0}^n A_{2m}^{2n} x^{2m} \quad (10)$$

where

$$A_{2m}^{2n} = (-1)^{n-m} \sum_{p=n-m}^n \binom{p}{p-n+m} \binom{2n}{2p}. \quad (11)$$

If (8) and (10) are inserted into (4) and (5) respectively, they become

$$G_{2N-1}(x) = \sum_{k=1}^N I_k \left\{ \sum_{m=1}^k A_{2m-1}^{2k-1} x^{2m-1} \right\}$$

and

$$G_{2N}(x) = \sum_{k=0}^N I_k \left\{ \sum_{m=0}^k A_{2m}^{2k} x^{2m} \right\}.$$

Since these last two equations involve finite double summations they can easily be rearranged to become respectively

$$G_{2N-1}(x) = \sum_{q=1}^N \sum_{k=q}^N I_k A_{2q-1}^{2k-1} x^{2q-1} \quad (12)$$

and

$$G_{2N}(x) = \sum_{q=0}^N \sum_{k=q}^N I_k A_{2q}^{2k} x^{2q}. \quad (13)$$

The difference between the lower limits in the outer summation sign of (12) and (13) arises because of the presence of a radiating element at the center of the array in the case of (13).

Equations (12) and (13) and their first derivatives with respect to u can be used to obtain the positions of the nulls and the side lobes of the radiation pattern of any symmetric in-phase broadside array. It is often true that the analytical processes involved are tedious if the number of elements in the array is large. The introduction of $y=x^2$ will materially simplify the analysis in all cases, however.

It is interesting to examine this type of representation for the case of the four-element array. This case exhibits all of the main points involved and is simple enough so that the mathematics does not present any difficulties. For a four-element array (4) becomes

$$F_4(u) = I_1 \cos u + I_2 \cos 3u.$$

Since $\cos 3u = 4 \cos^3 u - 3 \cos u$, this can be written as

$$G_3(x) = F_4(u) = x \{ 4I_2 x^2 + (I_1 - 3I_2) \}$$

where $x = \cos u, -1 \leq x \leq 1$.

The nulls therefore occur at $x=0$ and at

$$x_0 = \pm \sqrt{\frac{3 - \frac{I_1}{I_2}}{4}}. \quad (14)$$

The position of the side lobes are given by the roots of $dG_3(x)/du=0$. Thus the position of the main beam and the other in-phase lobes are given by

$$dx/du = -\sin u = 0$$

and the positions of the other side lobes by

$$\bar{x} = \pm \sqrt{\frac{3 - \frac{I_1}{I_2}}{12}}.$$

At these points $G_3(x)$ attains the value

$$|G_3(\bar{x})| = \frac{\sqrt{3}}{9} |I_2| \left| \left(3 - \frac{I_1}{I_2} \right)^{3/2} \right|.$$

The beam width is essentially given by the position of the first null which (14) determines. In this simple example, then, the beam width, the position of the side lobes, and the height or level of the side lobes are all functions of the same quantity, namely,

$$\left(3 - \frac{I_1}{I_2} \right).$$

The range of the ratio I_1/I_2 from $1 \leq I_1/I_2 \leq 3$ covers the range from the uniform distribution to the binomial. As the ratio increases over this range, it becomes apparent that the first null moves toward zero, so that the beam broadens and the side-lobe level drops until at the value of three the side lobes vanish altogether. It is also clear

that the beam can be made narrower than in the uniform case merely by choosing the range of I_1/I_2 from $0 \leq I_1/I_2 \leq 1$. The gain is of course a maximum for the uniform case.

It should be remarked again that, for larger arrays, it is in general impossible to devise physical means of achieving the range of current distribution from the uniform case to the binomial one because of the very large current ratios which become necessary in the latter case.

THE OPTIMUM CURRENT DISTRIBUTION

The distribution which will be deduced in this section has many properties in common with the distribution just discussed. As the taper is increased, the beam slowly broadens and the side-lobe level drops. It, however, possesses one great advantage: it is optimum in the sense that, once the side-lobe level is specified, the beam width (distance to first null) will be as small as possible; or, if the beam width is specified, the side-lobe level will be a minimum. Before demonstrating that this is always possible, it will be convenient to consider the nonnormalized Tchebyscheff polynomials. These are defined⁴ by

$$T_n(z) = \cos(n \arccos z). \quad (15)$$

To see that these are indeed polynomials of degree n in z , set $\phi = \arccos z$ and use (6). The nulls of these polynomials are given by the roots of $\cos n\phi = 0$, or by

$$\phi_k^0 = (2k - 1)\pi/2n, \quad k = 1, 2, \dots, n. \quad (16)$$

Further, $T_n'(z) = 0$ whenever $\sin n\phi = 0$, or when

$$\phi_k = k\pi/n, \quad k = 1, 2, \dots, n. \quad (17)$$

At the points ϕ_k , let $\bar{z}_k = \cos \phi_k$. Then $|T_n(\bar{z}_k)| = 1$. If one uses (15) as the definition, then clearly $-1 \leq z \leq 1$. However, considered as a polynomial in z , $T_n(z)$ exists for all z , $-\infty \leq z \leq \infty$. Moreover, if $z > 1$, then $T_n(z)$ is monotonically increasing, and if $z < -1$, it is either monotonically increasing or decreasing depending upon whether n is even or odd. Furthermore, $T_n^{(k)}(z)$ can only vanish for any k , ($k = 1, 2, \dots, n$) in the interval between $-1 \leq z \leq 1$. This is obviously true by induction, since $T_n(z)$ has n roots in this interval and $T_n'(z)$ has $n-1$ roots contained within the n roots of $T_n(z)$, etc.

Equations (8), (9), (10), and (11) lead to the following expressions, respectively:

$$T_{2N-1}(z) = \sum_{q=1}^N A_{2q-1}^{2N-1} z^{2q-1}; \quad -\infty \leq z \leq \infty \quad (18)$$

$$T_{2N}(z) = \sum_{q=0}^N A_{2q}^{2N} z^{2q}; \quad -\infty \leq z \leq \infty. \quad (19)$$

Now if the range of z is restricted to $-z_0 \leq z \leq z_0$, then clearly (18) and (19) can be reduced to polynomials of the form of (12) and (13) by introduction of the scale

⁴ Courant-Hilbert, "Methoden der Mathematischen Physik," vol. 1, pp. 75-76, Julius Springer, Berlin, 1931, and Interscience Publishers, Inc., New York, N.Y., 1943.

contraction given by $x = z/z_0$, whereas before $x = \cos u$. Written in terms of x , $-1 \leq x \leq 1$, (18) and (19) become

$$T_{2N-1}(z_0 x) = \sum_{q=1}^N A_{2q-1}^{2N-1} z_0^{2q-1} x^{2q-1} \quad (20)$$

and

$$T_{2N}(z_0 x) = \sum_{q=0}^N A_{2q}^{2N} z_0^{2q} x^{2q}. \quad (21)$$

Now if (20) is equated to (12), the following set of equations is obtained:

$$\sum_{k=q}^N I_k A_{2q-1}^{2k-1} = A_{2q-1}^{2N-1} z_0^{2q-1}, \quad q = 1, \dots, N.$$

These may be written in the form

$$I_q = \frac{1}{A_{2q-1}^{2q-1}} \left\{ A_{2q-1}^{2N-1} z_0^{2q-1} - \sum_{k=q+1}^N I_k A_{2q-1}^{2k-1} \right\}. \quad (22)$$

Similarly equating (21) to (13) yields

$$I_q = \frac{1}{A_{2q}^{2q}} \left\{ A_{2q}^{2N} z_0^{2q} - \sum_{k=q+1}^N I_k A_{2q}^{2k} \right\}. \quad (23)$$

It is clear that (22) and (23) can be solved for I_q , $q = 1, \dots, N$ in terms of z_0 by a step-wise process starting from $q = N$.

Thus, for each value of z_0 , the pattern as given by (12) or (13) can be made to agree with the pattern as given by (18) or (19). However, the characteristics of the latter expressions are completely known from the above discussion of the Tchebyscheff polynomials.

The parameter z_0 can be chosen in either of two ways: (1) the side-lobe level can be specified, or (2) the position of the first null can be specified.

In the first case, if the main-beam-to-side-lobe ratio is chosen to be $r/1$, it is necessary that z_0 satisfy the relation

$$T_M(z_0) = r; \quad z_0 \geq \cos(\pi/2M) \quad (24)$$

where

$$M = 2N-1 \text{ for an array of } 2N \text{ elements} \\ = 2N \text{ for an array of } 2N+1 \text{ elements.}$$

Once this value of z_0 has been determined and the current distribution computed from either (22) or (23), the pattern characteristics are completely known, since

(a) The side lobes are all equal and down on the main lobe in the ratio $1/r$.

(b) The nulls of the pattern are given by

$$u = \arccos[(\cos \phi_k^0)/z_0]; \quad k = 1, 2, \dots, N \quad (25)$$

where ϕ_k^0 are given by (16) and u by (3).

(c) The positions of the side lobes are given by

$$u = \arccos[(\cos \bar{\phi}_k)/z_0]; \quad k = 1, 2, \dots, N \quad (26)$$

where $\bar{\phi}_k$ is given by (17).

(d) The pattern between the nulls is given by

$$F(u) = \cos \{ M \arccos(z_0 \cos u) \} \quad (27)$$

or by

$$E(\theta) = \cos \left\{ M \arccos \left[z_0 \cos \left(\frac{\pi d}{\lambda} \sin \theta \right) \right] \right\}.$$

In the second case, if the first null is specified as θ_0 , it is necessary to compute x_1^0 from

$$x_1^0 = \cos u_1^0 = \cos \left(\frac{\pi d}{\lambda} \sin \theta_0 \right)$$

and to choose z_0 from the relation

$$z_0 = \frac{1}{x_1^0} \cos \frac{\pi}{2M} \quad (28)$$

$$\text{so that } T_M(z_0 x) = T_M \left[\left(\cos \frac{\pi}{2M} \right) x / x_1^0 \right]$$

will possess the necessary null at x_1^0 . In this case, also, the pattern is completely characterized once the current distribution has been determined, since the main-beam-to-side-lobe ratio is $(\sum I_k):1$ and since the nulls, side-lobe positions, and pattern between the nulls are again given by (25), (26), and (27), respectively, when the value of z_0 from (28) is inserted.

The distribution by the solutions of (22) and (23) possesses the following important optimum property in addition to the above advantages: (1) *If the side-lobe level is specified, the beam width (i.e., the number of degrees to the first null) is minimized; (2) if the first null is specified, the side-lobe level is minimized.*

The proof of these statements is contained in the following theorem, which is clearly applicable to polynomials of the form (12) and (13).

Theorem:⁴ Let $C(a)$ be a class of polynomials with real coefficients and of degree n having all of its roots in the interval $(-1, 1)$ such that

(1) If a polynomial $P(x)$ is in the class $C(a)$, then

$$P(x) = -P(-x) \quad \text{if } n \text{ is odd}$$

$$P(x) = P(-x) \quad \text{if } n \text{ is even}$$

$$P(1) = 1.$$

(2) If a polynomial $P(x)$ is in the class $C(a)$ and x_0 is its largest root (i.e., $|x_0|$ is a maximum among all the roots), then

$$|P(x)| \leq a \quad \text{whenever } |x| \leq |x_0| \leq 1.$$

Then

(1) There exists a polynomial $M(x)$ in $C(a)$ which maximizes $|x_0|$.

(2) The polynomial $M(x)$ is characterized by the fact that it just touches the lines $y = \pm a$ at $n-1$ points x_k within $|x| \leq x_0$.

Specifically, $M(x) = aT_n(z_0 x)$ where z_0 satisfies the relations

$$T_n(z_0) = \frac{1}{a}; \quad z_0 \geq \cos \left(\frac{\pi}{2n} \right).$$

To prove this theorem, consider any polynomial in the class $C(a)$ which is not $M(x)$. Let x_0 be its largest

root. Find y_0 from the relation

$$y_0 = \frac{\cos \left(\frac{\pi}{2n} \right)}{x_0} = z_1^0/x_0, \quad \text{where } z_1^0 = \cos \left(\frac{\pi}{2n} \right)$$

and construct the polynomial [which may or may not belong to $C(a)$]

$$Q(x) = AT_n \left(\frac{z_1^0 x}{x_0} \right);$$

$Q(x)$ therefore also possesses x_0 as the largest root. Determine A so that $Q(1) = 1$; then $Q(-1) = -1$ if n is odd and $Q(-1) = 1$ if n is even. $Q(x)$ is therefore a polynomial which has the same largest root at $P(x)$ and which, since it is just a modified Tchebyscheff polynomial, is such that $\max |Q(x)|$ is attained $n-1$ times between $-x_0 \leq x \leq x_0$.

Now it will be shown that

$$\max |Q(x)| < \max |P(x)|$$

when $|x| \leq |x_0|$ so that $Q(x)$ belongs to $C(b)$ contained in $C(a)$. Assume the contrary; namely, that

$$\max |Q(x)| \geq \max |P(x)| \quad (29)$$

when $|x| \leq |x_0|$. Form the difference polynomial

$$D(x) = Q(x) - P(x)$$

which is, *at most*, of degree n . However, by construction of $Q(x)$

$$D(1) = 0, \quad D(-1) = 0, \quad D(x_0) = 0.$$

Let x_k , $k=1, 2, n-1$, denote the $(n-1)$ points where $Q(x)$ attains its maximum value in the interval $|x| \leq |x_0|$, and evaluate $D(x)$ at these points under the assumption (29), so that

$$D(x_1) \leq 0, \quad D(x_2) \geq 0, \dots, \quad D(x_{n-1}) \leq 0.$$

Thus $D(x)$ experiences $(n-2)$ changes in sign between $(-x_0, x_0)$ and consequently it must possess $(n-2)$ additional roots in this interval. This makes the total number of roots $(n+1)$, which is obviously impossible, since $D(x)$ is, at most, of degree n . Consequently, (29) is false and it therefore follows that

$$b = \max |Q(x)| < \max |P(x)| \leq a \text{ when } |x| \leq |x_0| < 1.$$

Consequently, unless $P(x)$ is $M(x)$, a polynomial $Q(x)$ can always be constructed possessing the same largest root as $P(x)$ and belonging to a class of polynomials $C(b)$ which is contained in the class $C(a)$. It therefore follows that $M(x)$ is the one polynomial in $C(a)$ which maximizes $|x_0|$.

Physically speaking, the improvement in beam width given by the above type of distribution results from the raising of the side lobes at wide angles to the level of those near the main beam. From a practical viewpoint, this is inconsequential for two reasons: (1) if the side lobes are sufficiently low in level everywhere, it is of no importance that they fall off with increasing angle, and (2) the primary patterns of many types of

radiating elements fall off with increasing angle so that the final wide-angle lobes would be at a lower level than those close to the beam.

Theoretically at any rate, (2) suggests that a still greater improvement in beam width for a given side-lobe level might be obtained by devising a current distribution for the point sources in which the side lobes increased in magnitude with increasing angle in just the right proportion so that the superposition of the array pattern and that of the primary radiator would result in an over-all pattern possessing side lobes at the desired constant level.

ESTIMATION OF BEAM WIDTH TO OTHER THAN THE FIRST NULL

An estimate of the beam width to the half-power (3-decibel points) or to any other decibel point can be made readily if a plot of the side-lobe-level versus z_0 from (24) has been made over the appropriate range. Knowing the side-lobe level L in decibels, find from the curves of this type (see Appendix IV) the z_0 corresponding to this level. Also read from these curves the z_0' corresponding to $(L - R)$, where R is the number of decibels down on the maximum where the beam width is desired. The beam width in terms of u is then given by

$$u = \text{arc cos } (z_0'/z_0). \quad (30)$$

Again a plot of (3) can be used to give the beam width R decibels down on the maximum in terms of deviation from the normal to the array θ , or θ may be found directly from

$$\theta = \text{arc sin } \left\{ \frac{\lambda}{\pi d} \text{arc cos } (z_0'/z_0) \right\}. \quad (31)$$

EXAMPLES OF THE METHOD

A linear, in-phase, symmetric array consisting of eight elements will first be used by way of illustration. In this case (4) becomes the following: (The absolute value sign may be omitted.)

$$F_8(u) = I_1 \cos u + I_2 \cos 3u + I_3 \cos 5u + I_4 \cos 7u.$$

From this (see Appendix I) it is readily deduced that

$$\begin{aligned} G_7(x) &= x \{ 64I_4x^6 + (16I_3 - 112I_4)x^4 \\ &\quad + x^2(4I_2 - 20I_3 + 56I_4) \\ &\quad + |I_1 - 3I_2 + 5I_3 - 7I_4| \}. \end{aligned} \quad (32)$$

Furthermore, from Appendix I, if $\phi = \text{arc cos } z$, then

$$T_7(z) = \begin{cases} z[64z^6 - 112z^4 + 56z^2 - 7] & \text{if } -\infty \leq z \leq \infty \\ \cos 7\phi & \text{if } |z| \leq 1. \end{cases} \quad (33)$$

The following set of equations corresponding to (22) result when $G_7(x)$ is equated to $T_7(z_0x)$:

$$\begin{aligned} I_4 &= z_0^7 \\ I_3 &= 7I_4 - 7z_0^5 \\ I_2 &= 5I_3 - 14I_4 + 14z_0^3 \\ I_1 &= 3I_2 - 5I_3 + 7I_4 - 7z_0. \end{aligned} \quad (34)$$

Thus, once z_0 is determined from (24) or (28), the currents can be computed.

The pattern as a function of x is shown in Fig. 3 for $z_0 = 1.14$. This, as may be seen by referring to the plot of side-lobe level versus z_0 as given for an array of eight elements in Appendix IV, corresponds to a side-lobe level of 25.8 decibels.

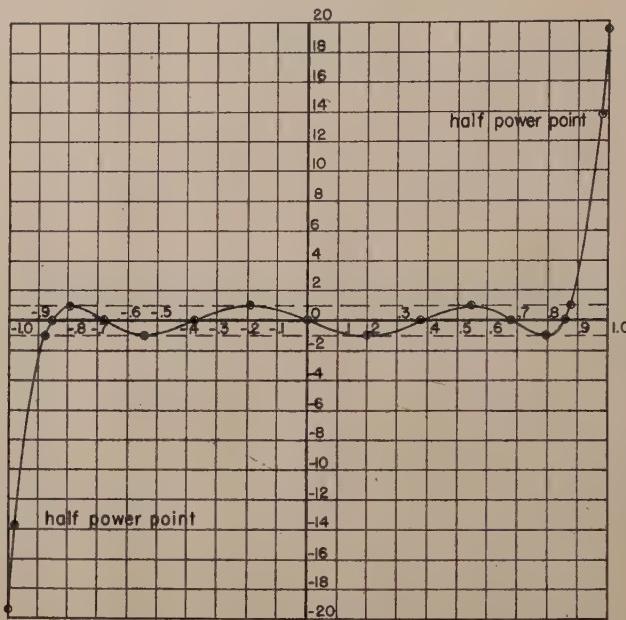


Fig. 3— $T_7(z_0)$ versus x . "The optimum pattern" as a function of x for an 8-element array with a 25.8-decibel side-lobe level. $z_0 = 1.14$.

This same pattern, replotted as a function of u , is shown in Fig. 4.

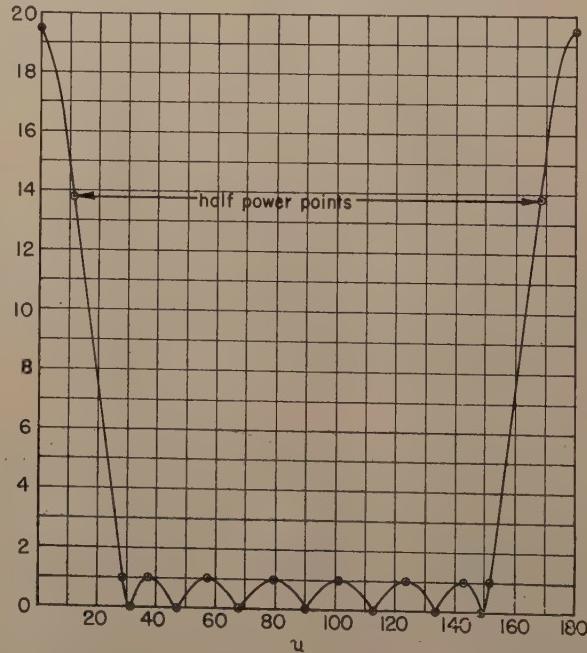


Fig. 4— $|F(u)| = |T_7(z_0 \cos u)|$ versus u for $z_0 = 1.14$. "The optimum pattern" as a function of u for an 8-element array with a 25.8-decibel side-lobe level.

Finally, this pattern is again replotted in terms of the physically measurable angle θ for the two spacing

wavelength ratios (d/λ) of one and one half in Fig. 5.

In all of these illustrations, only the circled points represent computed values. The data from which these

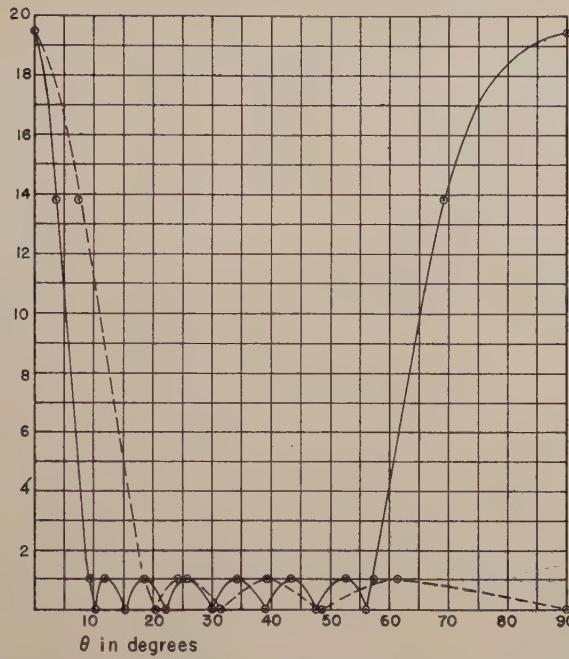


Fig. 5— $|E(\theta)| = |T_7[z_0 \cos \pi d/\lambda \sin \theta]|$ versus θ for $z_0 = 1.14$. "The optimum pattern" as a function of θ for half-wave and full-wave spacing for an 8-element array with a 25.8-decibel side-lobe level.

— $d/\lambda = 1$
- - - $d/\lambda = \frac{3}{2}$

curves were drawn are summarized below in Table I, in which

rows one and two give the position of the nulls as a function of ϕ_k^0 from (16);

row three gives the computed values of the nulls as a function of $\cos \phi_k^0$;

row four gives the nulls, as function of x corresponding to the scale contraction associated with $z_0 = 1.14$;

row five gives the position of the nulls as a function of u as obtained from $x = \cos u$ and equation (3);

rows six and seven give the position of the nulls as a function of θ for $d/\lambda = 1$ and $d/\lambda = \frac{3}{2}$, respectively.

The second half of the table summarizes this same information for the position of the side lobes. In it, the starting point, row eight, is obtained from (17).

Column I gives the recursion formulas which were used to compute the table to the right of the first double vertical line in each half from the values to the left of it.

In addition to the above values, all the figures have plotted on them the maximum points, the estimated half-power points, and the extreme points where the beam attains the side-lobe level in its ascent to a maximum value.

The maximum points correspond to the fact that a 25.8-decibel side-lobe level corresponds to a main-beam-to-side-lobe-level ratio of 19.45.

The estimated half-power points of value (0.707) times (19.48) or 13.8, were located by means of (30), (31), and the curve from Appendix IV referred to above. That is, the value of $z_0' = 1.116$ corresponding to 22.8 decibels (3 decibels down on the main-beam-to-side-lobe-level ratio) was obtained from this curve.

TABLE I
8-ELEMENT ARRAY

$z_0 = 1.14$										$Side-Lobe Level = 25.8 \text{ decibels}$	
Null Positions	A	B	C	D	E	F	G	H	I		
	k	1	2	3	4	5	6	7	8		
1	ϕ_k^0	$\frac{\pi}{14}$	$\frac{3\pi}{14}$	$\frac{5\pi}{14}$	$\frac{7\pi}{14}$	$\frac{9\pi}{14}$	$\frac{11\pi}{14}$	$\frac{13\pi}{14}$			
2		12.85 degrees	38.6 degrees	64.3 degrees	90 degrees	115.7 degrees	141.4 degrees	167.15 degrees		$\cos \phi = -\cos(\pi - \phi)$	
3	$z_k^0 = \cos \phi_k^0$	0.9750	0.7815	0.4337	0	-0.4337	-0.7815	-0.9750			
4	$x_k^0 = z_k^0/z_0$	0.854	0.685	0.380	0	-0.380	-0.685	-0.854			
5	$u_k^0 = \arccos z_k^0$	31.35 degrees	46.7 degrees	67.5 degrees	90 degrees	112.5 degrees	133.3 degrees	148.65 degrees		$ F(u) = F(\pi - u) $	
6	$d/\lambda = 1$ $\theta = \arcsin \frac{\lambda u}{\pi d}$	10 degrees	15.1 degrees	22.1 degrees	30 degrees	38.7 degrees	47.4 degrees	55.7 degrees			
7	$d/\lambda = \frac{3}{2}$ $\theta = \arcsin \frac{\lambda u}{\pi d}$	20.4 degrees	31.3 degrees	48.6 degrees	90 degrees						
Side-Lobe Positions	A	B	C	D	E	F	G	H	I		
	$\bar{\phi}_k$	$\frac{\pi}{7}$	$\frac{2\pi}{7}$	$\frac{3\pi}{7}$	$\frac{4\pi}{7}$	$\frac{5\pi}{7}$	$\frac{6\pi}{7}$	0			
8	$\bar{\phi}_k$	25.7 degrees	51.5 degrees	77.2 degrees	102.8 degrees	128.5 degrees	154.3 degrees	0/180 degrees			
9	$\bar{z}_k = \cos \bar{\phi}_k$	0.9011	0.6225	0.2215	-0.2215	-0.6225	-0.9011	+1		$\cos \phi = -\cos(\pi - \phi)$	
10	$\bar{x}_k = \frac{\bar{z}_k}{z_0}$	0.790	0.545	0.194	-0.194	-0.545	-0.790	-1			
11	$\bar{u}_k = \arccos \bar{x}_k$	36.8 degrees	56.9 degrees	78.8 degrees	101.2 degrees	123.1 degrees	143.2 degrees	0.876		$ F(u) = F(\pi - u) $	
12	$d/\lambda = 1$ $\theta = \arcsin \frac{\lambda u}{\pi d}$	11.8 degrees	18.4 degrees	25.9 degrees	34.1 degrees	43.2 degrees	52.7 degrees	-0.876			
13	$d/\lambda = \frac{3}{2}$ $\theta = \arcsin \frac{\lambda u}{\pi d}$	24.2 degrees	39.2 degrees	61.1 degrees				28.8 degrees 151.2 degrees 9.2 degrees 57.1 degrees 18.7 degrees			

This locates the half-power points in terms of x at $x = \pm 1.116/1.14 = \pm 0.9789$. Since $u = \arccos x$, this gives the location in terms of u at 11.8 and 168.2 degrees, respectively. For $d/\lambda = 1$, these in turn correspond to $\theta = 3.7$ and 69.2 degrees, respectively, giving an estimated total beam width of 7.4 degrees at the half-power points. For $d/\lambda = \frac{1}{2}$, the above values of u give a value of $\theta = 7.5$ degrees, or an estimated total beam width at the half-power points of 15 degrees.

Finally, it is clear from the general theory that the side-lobe level will be reached at extreme points corresponding to $\phi = 0, \pi$. The interpretation of these values in the x, u , and θ variables is carried through in column H in rows eight through thirteen.

It must be re-emphasized that, from the design viewpoint, all of the calculations tabulated in Table I are unnecessary, except perhaps the determination of the beam width at the half-power points. That is, practically, if the current distribution can be chosen to place the side lobe at an arbitrarily low level, it does not matter at all where they or the nulls occur. Table I is merely inserted as an aid to the understanding of the preceding theory, and for the sake of completeness.

LIMITING CASES OF THE OPTIMUM DISTRIBUTION

It is interesting to examine the design equation (34) for the two limiting cases of unit z_0 and infinite z_0 . In order to make this examination, it is first necessary to rewrite all of the currents as functions of z_0 . If this is done, (34) becomes

$$\begin{aligned}I_4 &= z_0^7 \\I_3 &= 7z_0^7 - 7z_0^5 \\I_2 &= 21z_0^7 - 35z_0^5 + 14z_0^3 \\I &= 35z_0^7 - 70z_0^5 + 42z_0^3 - 7z_0.\end{aligned}$$

Letting z_0 assume the value unity, all the I_k 's vanish except I_4 , which becomes unity, so that the pattern is proportional, by (3), to $\cos 7u$. In this case the side-lobe level is equal to that of the main beam. This result is, of course, expected because of the construction of this distribution.

In order to examine the case of infinite z_0 , consider the set of equations obtained by dividing the above set by I_4 .

$$\begin{aligned}I_4/I_4 &= 1 \\I_3/I_4 &= 7 - 7/z_0^2 \\I_2/I_4 &= 21 - 35/z_0^2 + 14/z_0^4 \\I_1/I_4 &= 35 - 70/z_0^2 + 42/z_0^4 - 7/z_0^6.\end{aligned}$$

Letting z_0 approach infinity, the currents take on the ratios 1, 7, 21, 35. These are recognized as the binomial coefficients of the expansion $(a+b)^7$. In this case the pattern is well known to be proportional to $(\cos u)^7$ and contains no side lobes whenever u is restricted to the range $0 \leq u \leq (\pi/2)$. Thus, it is apparent that the above theory covers the entire range of side-lobe levels. It should be added that, whenever design equations are

derived, these two limiting cases can be used as a convenient check.

Similarly, a seven-element array will be used as an illustration. In this case (5) becomes

$$F_7(u) = I_0 + I_1 \cos 2u + I_2 \cos 4u + I_3 \cos 6u.$$

Letting $x = \cos u$ and using (13), this can be written as

$$G_6(x) = 32I_3x^6 + (8I_2 - 48I_3)x^4$$

$$+ (2I_1 - 8I_2 + 18I_3)x^2 + (I_0 - I_1 + I_2 - I_3),$$

since $\cos 2u = 2x^2 - 1$

$$\cos 4u = 8x^4 - 8x^2 + 1$$

$$\cos 6u = 32x^6 - 48x^4 + 18x^2 - 1.$$

Similarly, if $\phi = \arccos z$

$$T_6(z) = 32z^6 - 48z^4 + 18z^2 - 1; -\infty \leq z \leq \infty$$

$$= \cos 6\phi; -1 \leq z \leq 1$$

so that if the identification corresponding to (24) or (28) is made, the following design equations are obtained:

$$I_3 = z_0^6$$

$$I_2 = 6I_3 - 6z_0^4$$

$$I_1 = 4I_2 - 9I_3 + 9z_0^2$$

$$I_0 = I_1 - I_2 + I_3 - 1.$$

Since the construction of a table like the one given for the eight-element array proceeds almost as before and results in figures similar to 3, 4, and 5, no further details will be given here for the seven-element case. Moreover, because the author has been involved in the design of linear arrays of $2N$ elements exclusively, the detailed calculations and curves to be found in the appendixes are given for this case only.

It should be remarked that, if the current ratios are computed by formulas like (34) and those in Appendix III, and not normalized, then

$$20 \log \sum I_k$$

gives the side-lobe level in decibels at once.

Appendix I contains the Tchebyscheff polynomials of the form $\cos(2n-1)\phi$ for $n = 1, \dots, 12$.

Appendix II gives the formula for $G_{23}(x)$ for an array of 24 elements. The appropriate formulas for shorter arrays of $2N$ elements can be deduced instantly merely by setting the excess I_k equal to zero.

Appendix III contains the design equations similar to (34) for this type of distribution of arrays consisting of 12, 16, 20, and 24 elements.

Appendix IV gives design curves for arrays of this type consisting of 8, 12, 16, 20, and 24 elements. These curves are given for a range of 26- to 40-decibel side-lobe level and show

(1) the variation of the side-lobe level with z_0 ;

(2) the variation of the currents as a function of the side-lobe level;

(3) the reduction in power gain from a uniform array consisting of the same number of elements as a function

of the side-lobe level for 8-, 12-, and 24-element arrays under the assumption that the mutual impedances between the elements are zero.

In this, the power-gain reduction from a uniform array is given by the well-known and easily derivable formula

$$G = \frac{\left(\sum_1^N I_k \right)^2}{N \left(\sum_1^N I_k^2 \right)}$$

for symmetrical arrays of $2N$ elements.

If the mutual impedances between the elements are small but not zero, the above formula is still a good approximation to the gain reduction that can be expected.

COMPARISON OF THE BEAM WIDTH OF A UNIFORM ARRAY AND THE TCHEBYSCHEFF DISTRIBUTION

If all the I_k 's are equal, then it is easily shown that (4) can be written (for an array of $2N$ elements) as

$$F(u) = \frac{1}{2} \frac{\sin 2Nu}{\sin u} = \sum_{k=0}^{N-1} \cos (2k - 1)u.$$

The first null of this is therefore given by

$$\sin 2Nu = 0, \quad \text{or} \quad u = \pi/2N.$$

The corresponding first null for a Tchebyscheff distribution is given by

$$u = \arccos \left\{ \frac{1}{z_0} \cos \frac{\pi}{2(2N-1)} \right\}$$

so that, as in the general case, z_0 can be chosen so as to make the first null either equal to that of the uniform case or smaller than that.

A moment's reflection therefore shows that, when the side-lobe level starts to approach that of the uniform case, inversions must necessarily appear in the Tchebyscheff distribution. This explains the fact that the curves in Appendix IV sometimes cross.

RECTANGULAR ARRAYS

For the purpose of the ensuing discussion it is convenient to locate a co-ordinate system at the center 0 of the outer rectangle enclosing the array. Let the x , y axes of this co-ordinate system be parallel to the sides of the rectangle. Let the constant spacing between the elements in the x , y directions be (a) , (b) , respectively. Assume that there is a radiating element at 0. With these conventions, the various radiating elements will be located at points (pa, qb) where p, q take on positive and negative integral values including zero. In the general case, these radiating elements can be fed with currents possessing arbitrary amplitudes and phase with respect to the element at 0. However, if the distribution of currents in any column, row is proportional to that of any other column, row respectively, then the 2-dimensional array factor S_{xy} is the product of two 1-dimensional array factors S_x and S_y . Here S_x may be taken

for convenience as the array factor arising from the distribution of currents in the radiating elements along the x axis. Similarly, S_y may be thought of as arising from the distribution of currents in the radiating elements along the y axis.

If the angles are as in Fig. 6, and if α_p, β_q represent any phase shift which may be introduced in radiating

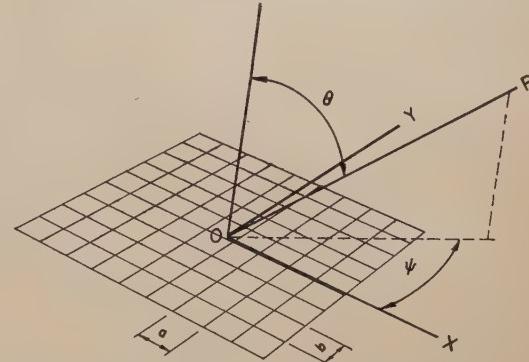


Fig. 6.—Reference system for a two-dimensional array of point sources.

elements located at $(pa, 0)$ and $(0, qb)$, respectively, then the 2-dimensional array factor S_{xy} for a rectangular array possessing $2M+1$ elements parallel to the x axis and $(2N+1)$ elements parallel to the y axis is given by

$$S_{xy} = \left| \left\{ \sum_{p=-M}^M A_p \exp \left[jp \frac{2\pi}{\lambda} a \sin \theta \cos \psi + j\alpha_p \right] \right\} \right. \\ \left. \left\{ \sum_{q=-N}^N B_q \exp \left[jq \frac{2\pi}{\lambda} b \sin \theta \sin \psi + j\beta_q \right] \right\} \right|. \quad (35)$$

In order to apply the above 1-dimensional theory to either S_x or S_y , the factors of S_{xy} , it is merely necessary to set all the α_p 's, β_q 's, respectively, equal to zero and to impose the conditions that

$$A_p = A_{(-p)}; \quad \psi = 0$$

or that

$$B_q = B_{(-q)}; \quad \psi = \pi/2.$$

If this is done in the case of S_x , as would be convenient if a sharp azimuth pattern were desired, it would become

$$S_x = \left| A_0 + 2 \sum_{p=1}^M A_p \cos \left(2p \frac{\pi}{\lambda} a \sin \theta \right) \right|.$$

Letting $v = (\pi/\lambda)a \sin \theta$, this last equation becomes

$$S_x = \left| A_0 + 2 \sum_{p=1}^M A_p \cos (2pv) \right|. \quad (36)$$

Equation (36) is recognized as being in the same form as (5) and therefore the same design procedure applicable there should be used here. If a sharp vertical pattern is desired, S_y can be treated in a similar fashion. On the other hand, if a different type of pattern is desired, the usual techniques can be applied to determine the appropriate values of B_q .

In either event, the pattern will be given by (35). The actual current to be fed into the element located at

(pa, qb) is of course $A_p B_q e^{j(\alpha_p + \beta_q)}$ in all cases.

It is unfortunate, perhaps, that the design curves contained in the appendix were not computed for (36) and hence cannot be used to sharpen the pattern in one or both directions. However, if the column and the row of radiators passing through the center 0 is struck out, as well as every other column and row, then the resulting expressions are just those computed in the appendix. Explicitly, if

$$A_0 = 0 \quad B_0 = 0$$

$$A_{2p} = 0 \quad B_{2q} = 0 \quad p = 1, 2, \dots, M \\ q = 1, 2, \dots, N$$

then the separation between the elements along the x, y directions is, respectively, (2a) and (2b). Let these be denoted by (d) and (d') , respectively. Then if

$$w = \frac{\pi d}{\lambda} \sin \theta$$

and it is desired to apply the theory to the x direction, so that $\alpha_p = 0$, equation (36) becomes

$$\frac{S_x}{2} = \left| \sum_{p=1}^M A_p \cos(2p - 1)w \right|.$$

This is recognized as of the same form as (4) so that the curves contained in the appendixes are applicable. S_y can be treated similarly or again made to conform with any other desired distribution.

EXPERIMENTAL VERIFICATION

The preceding theory has been utilized in the design of several linear arrays with excellent results.

Specifically, 12- and 24-element arrays of directive elements with $(4/5\lambda)$ spacing at the mid-band frequency have been successfully built and made to operate over a ± 10 per cent band with a 26-decibel side-lobe level. Both of the arrays were designed for a side-lobe level of 32 decibels and at the high end of the frequency band the 12-element array actually possessed a side-lobe level of 31 decibels. The performance of the 24-element array, while excellent, did not show as close an agreement with the predicted performance because of its greater complexity.

The beam widths to the half-power points were of the order of 6 degrees and 3 degrees, respectively, at the mid-band frequency and showed a total variation of about 1 degree over the band.

This experience, while admittedly limited, is sufficient to indicate that the above theory can be used successfully as a basis for design provided that a safety factor of from 3 to 5 decibels is allowed in the side-lobe level. This discrepancy between theory and practice is partly due to constructional difficulties and partly due to the finite size of the reflector behind the point sources in a physical array.

APPENDIX I

The nonnormalized Tchebyscheff polynomials

$$\cos(2n - 1)\theta, \quad n = 1, 2, \dots, 10$$

$$\cos \theta = x$$

$$\cos 3\theta = x\{4x^2 - 3\}$$

$$\cos 5\theta = x\{16x^4 - 20x^2 + 5\}$$

$$\cos 7\theta = x\{64x^6 - 112x^4 + 56x^2 - 7\}$$

$$\cos 9\theta = x\{256x^8 - 576x^6 + 432x^4 - 120x^2 + 9\}$$

$$\cos 11\theta = x\{1024x^{10} - 2816x^8 + 2816x^6$$

$$- 1232x^4 + 220x^2 - 11\}$$

$$\cos 13\theta = x\{4096x^{12} - 13,312x^{10} + 16,640x^8 \\ - 9984x^6 + 2912x^4 - 364x^2 + 13\}$$

$$\cos 15\theta = x\{16,384x^{14} - 61,440x^{12} + 92,160x^{10} \\ - 70,400x^8 + 28,800x^6 - 6048x^4$$

$$+ 560x^2 - 15\}$$

$$\cos 17\theta = x\{65,536x^{16} - 278,528x^{14} + 487,424x^{12} \\ - 452,608x^{10} + 239,360x^8 - 71,808x^6 \\ + 11,424x^4 - 816x^2 + 17\}$$

$$\cos 19\theta = x\{262,144x^{18} - 1,245,184x^{16} + 2,490,368x^{14} \\ - 2,723,840x^{12} + 1,770,496x^{10} - 695,552x^8 \\ + 160,512x^6 - 20,064x^4 + 1140x^2 - 19\}$$

$$\cos 21\theta = x\{1,048,576x^{20} - 5,505,024x^{18} + 12,386,304x^{16} \\ - 15,597,568x^{14} + 12,042,240x^{12} \\ - 5,870,592x^{10} + 1,793,792x^8 - 329,472x^6 \\ + 33,264x^4 - 1540x^2 + 21\}$$

$$\cos 23\theta = x\{4,194,304x^{22} - 24,117,248x^{20} + 60,293,120x^{18} \\ - 85,917,696x^{16} + 76,873,728x^{14} \\ - 44,843,008x^{12} + 17,145,856x^{10} \\ - 4,209,920x^8 + 631,488x^6 - 52,624x^4 \\ + 2024x^2 - 23\}.$$

Check:

$$\text{If } x = 1, \cos n\theta = 1.$$

APPENDIX II

24-ELEMENT ARRAY

$$G_{23}(x) = x\{4,194,304I_{12}x^{22} + (-24,117,248I_{12} \\ + 1,048,576I_{11})x^{20} + (60,293,120I_{12} \\ - 5,505,024I_{11} + 262,144I_{10})x^{18} \\ + (-85,917,696I_{12} + 12,386,304I_{11} \\ - 1,245,184I_{10} + 65,536I_9)x^{16} + (76,873,728I_{12} \\ - 15,597,568I_{11} + 2,490,368I_{10} - 278,528I_9 \\ + 16,384I_8)x^{14} + (-44,843,008I_{12} \\ + 12,042,240I_{11} - 2,723,840I_{10} + 487,424I_9 \\ - 61,440I_8 + 4096I_7)x^{12} + (17,145,856I_{12} \\ - 5,870,592I_{11} + 1,770,496I_{10} - 452,608I_9 \\ + 92,160I_8 - 13,312I_7 + 1024I_6)x^{10}$$

$$\begin{aligned}
 & + (-4,209,920I_{12} + 1,793,792I_{11} - 695,552I_{10} \\
 & + 239,360I_9 - 70,400I_8 + 16,640I_7 - 2816I_6 \\
 & + 256I_5)x^8 + (631,488I_{12} - 329,472I_{11} \\
 & + 160,512I_{10} - 71,808I_9 + 28,800I_8 - 9984I_7 \\
 & + 2816I_6 - 576I_5 + 64I_4)x^6 + (-52,624I_{12} \\
 & + 33,264I_{11} - 20,064I_{10} + 11,424I_9 - 6048I_8 \\
 & + 2912I_7 - 1232I_6 + 432I_5 - 112I_4 + 16I_3)x^4 \\
 & + (2024I_{12} - 1540I_{11} + 1140I_{10} - 816I_9 \\
 & + 560I_8 - 364I_7 + 220I_6 - 120I_5 + 56I_4 \\
 & - 20I_3 + 4I_2)x^2 + (-23I_{12} + 21I_{11} - 19I_{10} \\
 & + 17I_9 - 15I_8 + 13I_7 - 11I_6 + 9I_5 - 7I_4 \\
 & + 5I_3 - 3I_2 + I_1) \}.
 \end{aligned}$$

Check:

$$\begin{aligned}
 G_{23}(1) = & I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 + I_8 + I_9 \\
 & + I_{10} + I_{11} + I_{12}.
 \end{aligned}$$

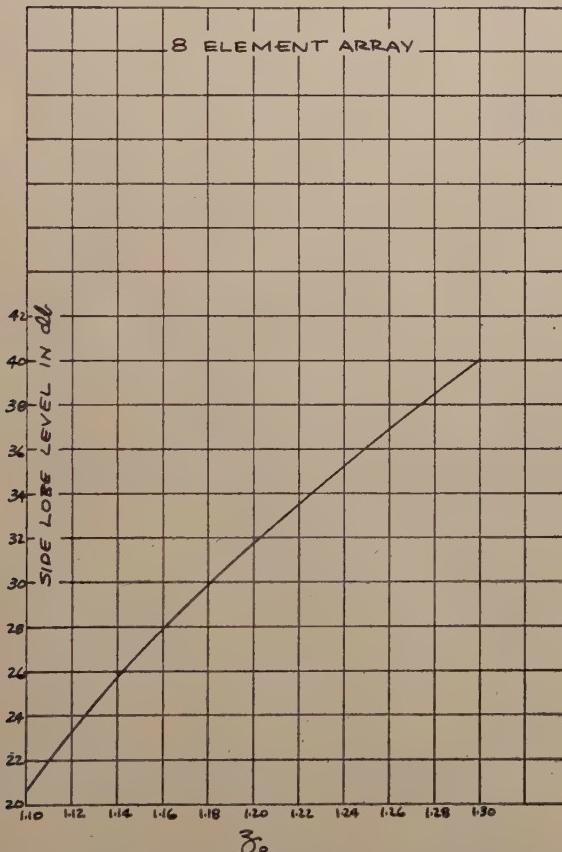


Fig. 7.—The side-lobe level in decibels for "the optimum current distribution" as a function of the scale-contraction factor z_0 for an 8-element array.

APPENDIX III

DESIGN EQUATIONS FOR

12-ELEMENT ARRAY

$$I_6 = z_0^{11}$$

$$I_5 = 11(I_6 - z_0^9)$$

$$I_4 = 9I_5 - 44I_6 + 44z_0^7$$

$$I_3 = 7I_4 - 27I_5 + 77I_6 - 77z_0^5$$

$$I_2 = 5I_3 - 14I_4 + 30I_5 - 55I_6 + 55z_0^3$$

$$I_1 = 3I_2 - 5I_3 + 7I_4 - 9I_5 + 11I_6 - 11z_0$$

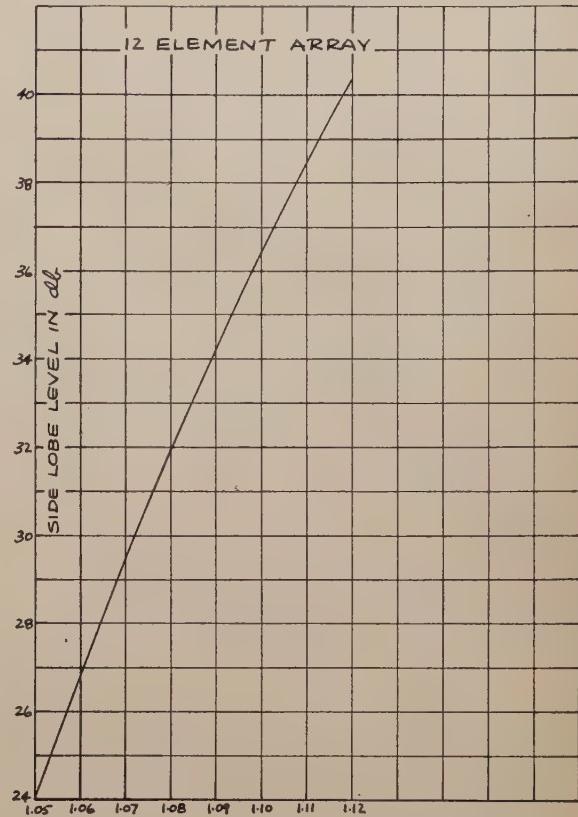


Fig. 8.—The side-lobe level in decibels for "the optimum current distribution" as a function of the scale-contraction factor z_0 for a 12-element array.

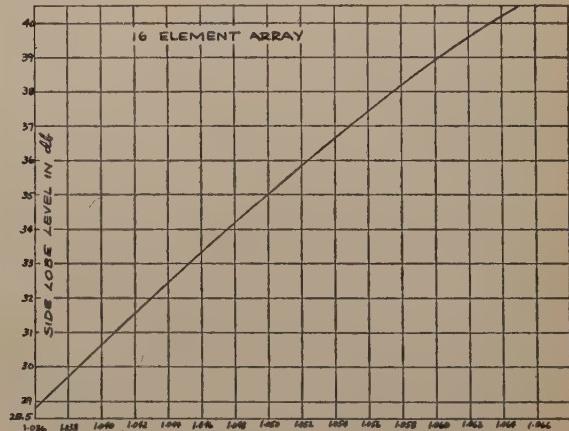


Fig. 9.—The side-lobe level in decibels for "the optimum current distribution" as a function of the scale-contraction factor z_0 for a 16-element array.

16-ELEMENT ARRAY

$$I_8 = z_0^{15}$$

$$I_7 = 15I_8 - 15z_0^{13}$$

$$I_6 = 13I_7 - 90I_8 + 90z_0^{11}$$

$$I_5 = 11I_6 - 65I_7 + 275I_8 - 275z_0^9$$

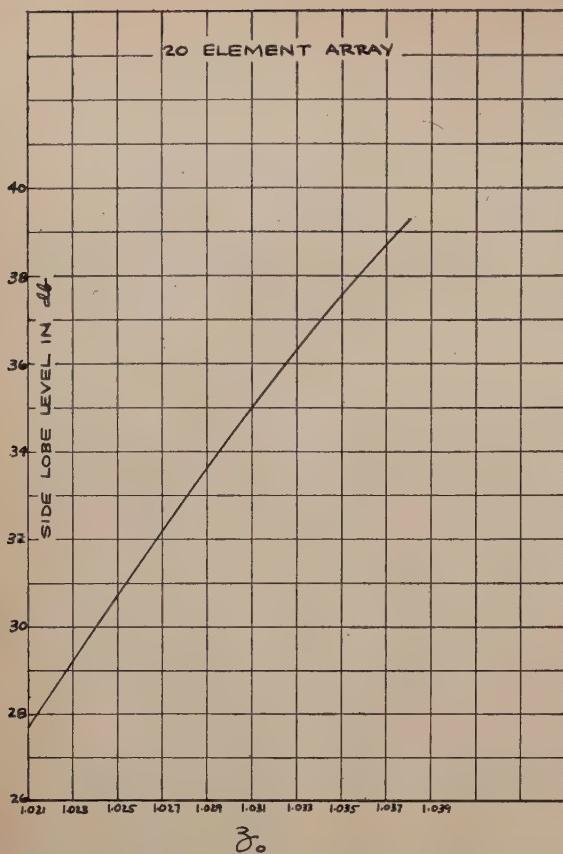


Fig. 10.—The side-lobe level in decibels for “the optimum current distribution” as a function of the scale-contraction factor z_0 for a 20-element array.

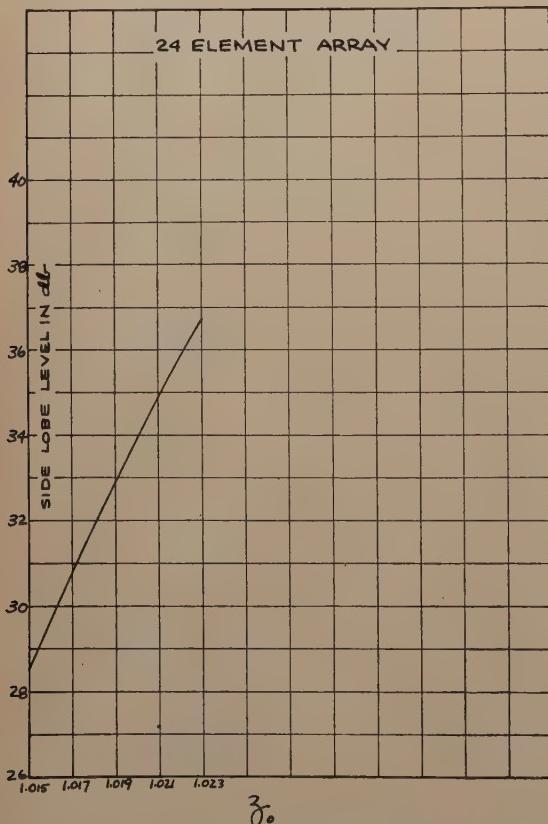


Fig. 11.—The side-lobe level in decibels for “the optimum current distribution” as a function of the scale-contraction factor z_0 for a 24-element array.

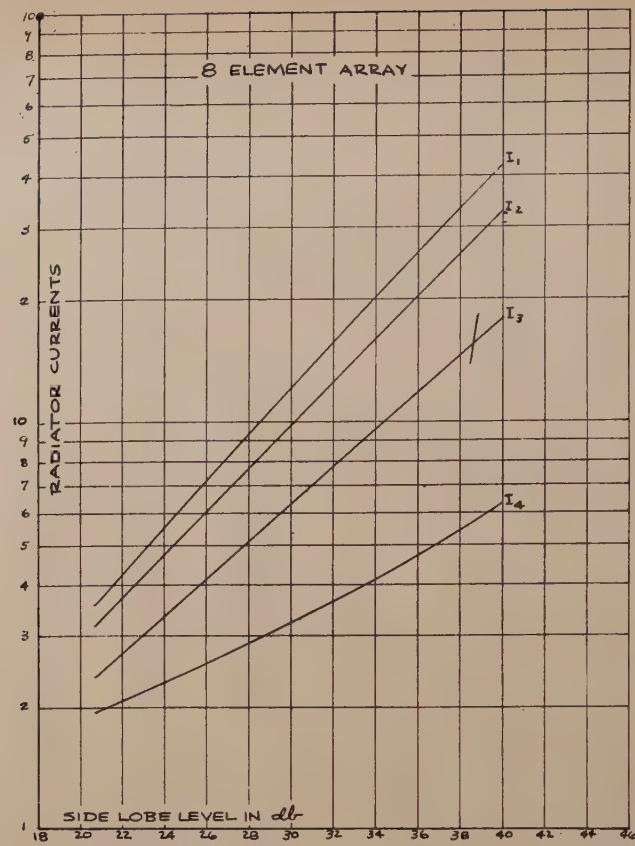


Fig. 12.—The relative current values for an 8-element array necessary for “the optimum current distribution” as a function of side-lobe level in decibels.

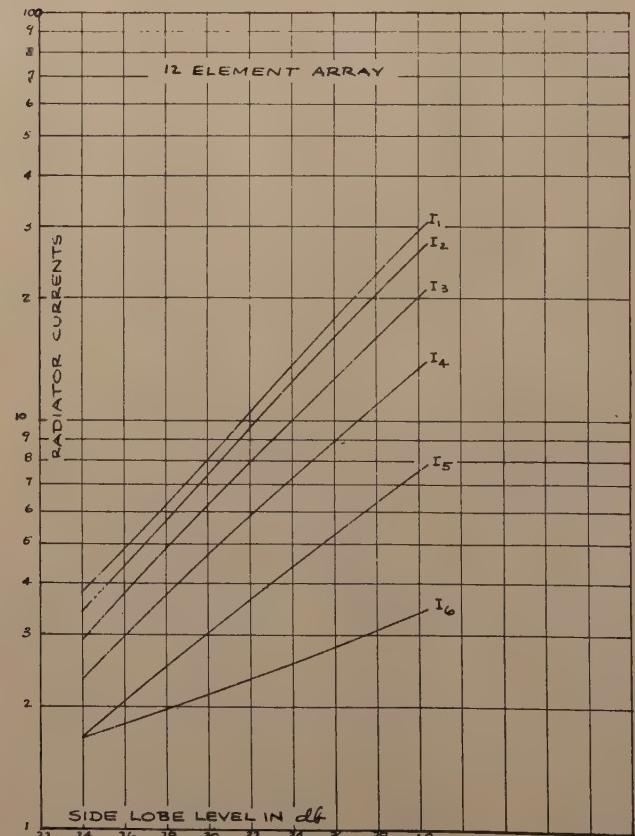


Fig. 13.—The relative current values for a 12-element array necessary for “the optimum current distribution” as a function of side-lobe level in decibels.

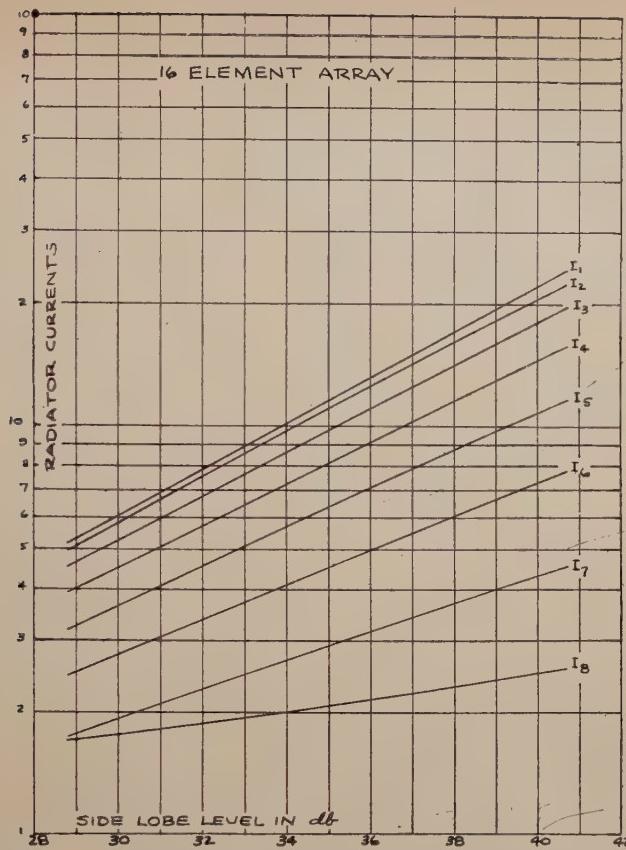


Fig. 14—The relative current values for a 16-element array necessary for "the optimum current distribution" as a function of side-lobe level in decibels.

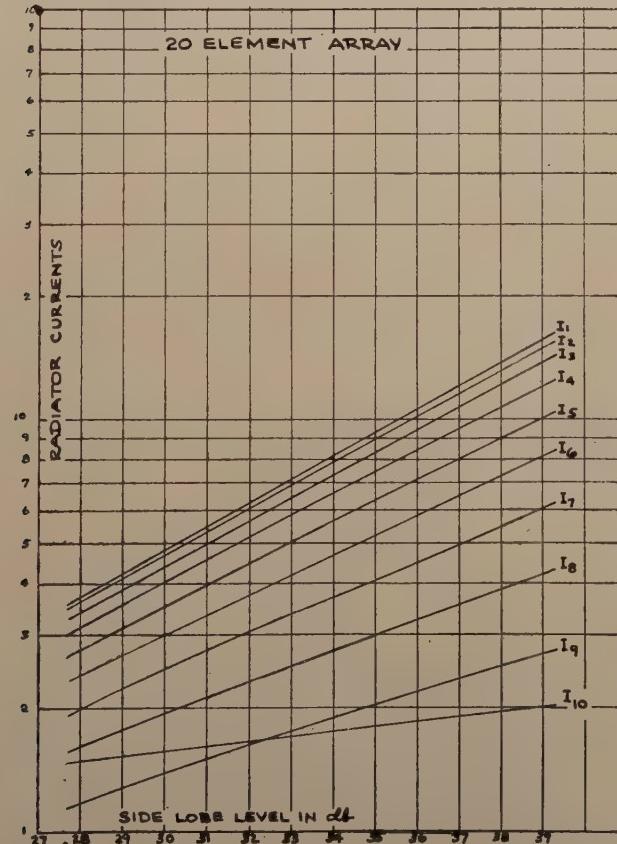


Fig. 15—The relative current values for a 20-element array necessary for "the optimum current distribution" as a function of side-lobe level in decibels.

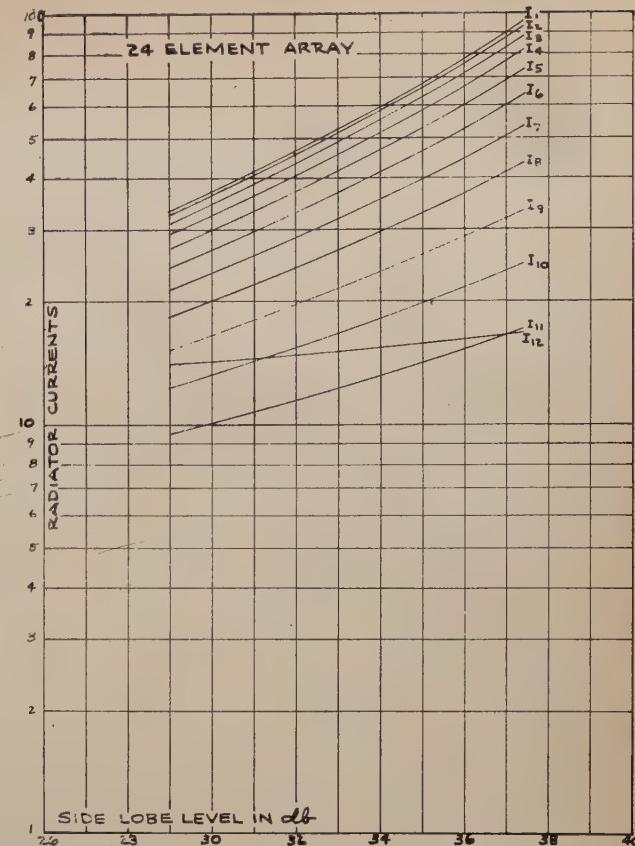


Fig. 16—The relative current values for a 24-element array necessary for "the optimum current distribution" as a function of side-lobe level in decibels.

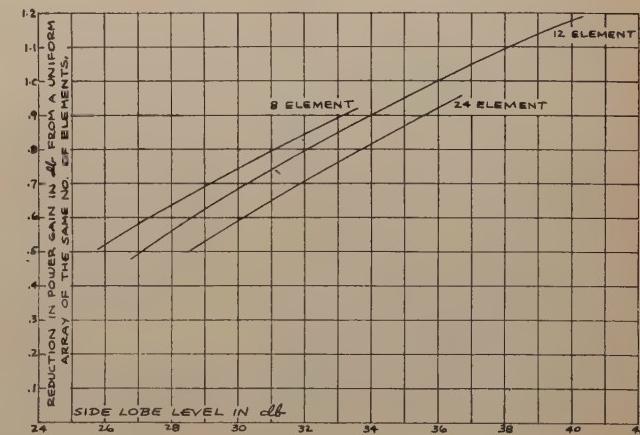


Fig. 17—The power-gain reduction of "the optimum current distribution" with respect to a "uniform" array of the same number of elements as a function of side-lobe level in decibels for 8-, 12-, and 24-element arrays, under the assumption that mutual impedances between the radiators are negligible.

$$I_4 = 9I_5 - 44I_6 + 156I_7 - 450I_8 + 450z_0^7$$

$$I_3 = 7I_4 - 27I_5 + 77I_6 - 182I_7 + 378I_8 - 378z_0^5$$

$$I_2 = 5I_3 - 14I_4 + 30I_5 - 55I_6 + 91I_7 - 140I_8 \\ + 140z_0^3$$

$$I_1 = 3I_2 - 5I_3 + 7I_4 - 9I_5 + 11I_6 - 13I_7 \\ + 15I_8 - 15z_0.$$

20-ELEMENT ARRAY

$$\begin{aligned}
 I_{10} &= z_0^{19} \\
 I_9 &= 19I_{10} - 19z_0^{17} \\
 I_8 &= 17I_9 - 152I_{10} + 152z_0^{15} \\
 I_7 &= 15I_8 - 119I_9 + 665I_{10} - 665z_0^{13} \\
 I_6 &= 13I_7 - 90I_8 + 442I_9 - 1729I_{10} + 1729z_0^{11} \\
 I_5 &= 11I_6 - 65I_7 + 275I_8 - 935I_9 + 2717I_{10} \\
 &\quad - 2717z_0^9 \\
 I_4 &= 9I_5 - 44I_6 + 156I_7 - 450I_8 + 1121I_9 - 2508I_{10} \\
 &\quad + 2508z_0^7 \\
 I_3 &= 7I_4 - 27I_5 + 77I_6 - 182I_7 + 378I_8 - 714I_9 \\
 &\quad + 1254I_{10} - 1254z_0^5 \\
 I_2 &= 5I_3 - 14I_4 + 30I_5 - 55I_6 + 91I_7 - 140I_8 \\
 &\quad + 204I_9 - 285I_{10} + 285z_0^3 \\
 I_1 &= 3I_2 - 5I_3 + 7I_4 - 9I_5 + 11I_6 - 13I_7 + 15I_8 \\
 &\quad - 17I_9 + 19I_{10} - 19z_0.
 \end{aligned}$$

24-ELEMENT ARRAY

$$\begin{aligned}
 I_{12} &= z_0^{23} \\
 I_{11} &= 23I_{12} - 23z_0^{21} \\
 I_{10} &= 21I_{11} - 230I_{12} + 230z_0^{19} \\
 I_9 &= 19I_{10} - 189I_{11} + 1311I_{12} - 1311z_0^{17} \\
 I_8 &= 17I_9 - 152I_{10} + 952I_{11} - 4692I_{12} + 4692z_0^{15}
 \end{aligned}$$

$$\begin{aligned}
 I_7 &= 15I_8 - 119I_9 + 665I_{10} - 2940I_{11} + 10,948I_{12} \\
 &\quad - 10,948z_0^{13} \\
 I_6 &= 13I_7 - 90I_8 + 442I_9 - 1729I_{10} + 5733I_{11} \\
 &\quad - 16,744I_{12} + 16,744z_0^{11} \\
 I_5 &= 11I_6 - 65I_7 + 275I_8 - 935I_9 + 2717I_{10} \\
 &\quad - 7007I_{11} + 16,445I_{12} - 16,445z_0^9 \\
 I_4 &= 9I_5 - 44I_6 + 156I_7 - 450I_8 + 1122I_9 \\
 &\quad - 2508I_{10} + 5148I_{11} - 9867I_{12} + 9867z_0^7 \\
 I_3 &= 7I_4 - 27I_5 + 77I_6 - 182I_7 + 378I_8 - 714I_9 \\
 &\quad + 1254I_{10} - 2079I_{11} + 3289I_{12} - 3289z_0^5 \\
 I_2 &= 5I_3 - 14I_4 + 30I_5 - 55I_6 + 91I_7 - 140I_8 \\
 &\quad + 204I_9 - 285I_{10} + 385I_{11} - 506I_{12} + 506z_0^3 \\
 I_1 &= 3I_2 - 5I_3 + 7I_4 - 9I_5 + 11I_6 - 13I_7 + 15I_8 \\
 &\quad - 17I_9 + 19I_{10} - 21I_{11} + 23I_{12} - 23z_0.
 \end{aligned}$$

APPENDIX IV

The accompanying design curves are shown for broadside, symmetric arrays of 8, 12, 16, 20, and 24 elements over an approximate side-lobe-level range of 26 to 40 decibels.

Figs. 7, 8, 9, 10, and 11 are useful in estimating beam widths to half-power points.

Figs. 12, 13, 14, 15, and 16 give the relative current values needed in design.

Fig. 17 is useful in predicting power-gain performance.

High-Impedance Cable*

HEINZ E. KALLMANN†, SENIOR MEMBER, I.R.E.

Summary—A cable with an impedance of the order of 1000 ohms is described. It resembles the usual flexible concentric cable with a 3/8-inch outside diameter, but its inner conductor is a single-layer coil continuously wound on a flexible core of 0.110-inch diameter. The cable is suitable for video connections from chassis to chassis and to remote indicators.

PRESENT types of video amplifiers are built with load impedances of the order of 1000 ohms; the cables, however, now used for video signals have impedances of 50 to 100 ohms, with capacitances of 30 to 100 micromicrofarads per meter. They may be matched to correspondingly low load resistances, or they may be treated as lumped load capacitances, in either case enforcing low gain and low peak-voltage output available from a given tube.

* Decimal classification: R117.2×R282.1. Original manuscript received by the Institute, January 7, 1946; revised manuscript received, February 27, 1946. This paper is based on work done for the Office of Scientific Research and Development under contract OEMsr-262 with the Radiation Laboratory, Massachusetts Institute of Technology. The cable described herein was subsequently produced by the Federal Telephone and Radio Corporation under contract OEMsr-1283.

† Formerly, Radiation Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts; now, consulting engineer, New York, N. Y.

To avoid these losses, cables having much higher surge impedances are desirable. A suitable design can be derived from that used for delay lines of the distributed-parameter type, but with dimensions modified so as to yield the high impedance Z_0 with the least possible signal delay and attenuation per unit length. To this end, the inductance L per unit length is increased, while the capacitance C is kept low, since

$$Z_0 = \sqrt{L/C} \text{ (ohms, henries, farads).} \quad (1)$$

An experimental cable was made, resembling a low-capacitance concentric cable except that the inner conductor was a small-diameter single-layer coil, continuously wound on a flexible core, as shown with dimensions in Figs. 1 and 2. The core, 0.060-inch thick, was made of Saran, a moderately flexible plastic; the inner conductor was close-wound on it with No. 34 HF Formex wire. A helix wound from 0.065-inch polystyrene with 0.15-inch pitch was used as a spacer, with an outer diameter of about 0.25 inch. The outer conductor was 3/16-inch braid of 175 tinned 0.005-inch copper wires. The cable, with an outside diameter of 5/16 inch, can be bent to a 2-inch diameter circle.

A few short samples were made and one continuous piece of cable 24 feet in length. Its total capacitance C was 365 micromicrofarads, and its delay T was 0.462 microseconds at low frequencies, dropping steadily to 0.459 microsecond at 22 megacycles, as shown in Fig. 3.

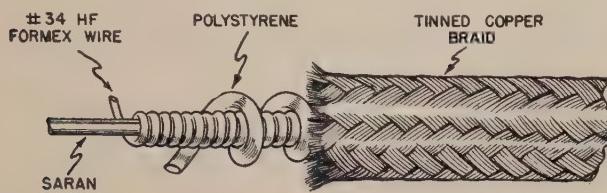


Fig. 1—Construction of experimental cable.

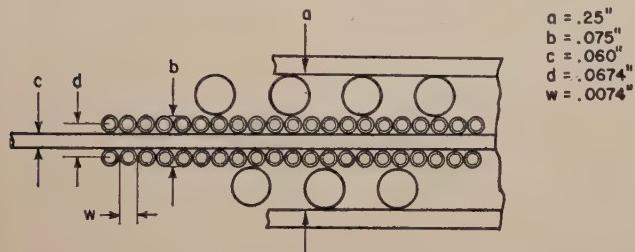


Fig. 2—Dimensions of experimental cable.

Its impedance was thus 1260 ohms, since from (1) for the impedance and from (2) for the time delay¹

$$T = LC \text{ (seconds, henries, farads)} \quad (2)$$

follows equation (3)

$$Z = T/Z \text{ (ohms, seconds, farads).} \quad (3)$$

The direct-current resistance was 200 ohms; the transmission loss was found to rise steadily from 0.7 decibel at very low frequencies to 1.7 decibels at 5 megacycles, and to 3.3 decibels at 10 megacycles, as plotted in Fig. 4. Very satisfactory transmission of short pulses confirmed expectations.

The type of cable shown in Fig. 5, now in production as type RG-65/U, is built more solidly, sacrificing some of the above electrical characteristics. In particular, an inner conductor wound of No. 34 American Wire Gauge

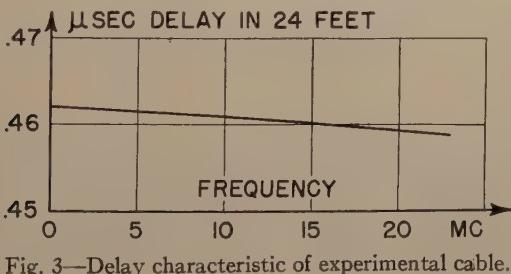


Fig. 3—Delay characteristic of experimental cable.

has a smaller diameter than is now believed mechanically safe. Future experience will show just how fine a wire is safe; but the wire diameter is the most consequential

¹ William L. Everitt, "Communication Engineering," McGraw-Hill Book Company, New York, N.Y., 1937, chap. 4, pp. 94-128, equations (35c) and (36a).

design parameter, as will be understood from the following analysis:

- Let a = inside diameter of outer conductor, in centimeters;
- b = outside diameter of coil, in centimeters;
- c = diameter of coil core, in centimeters;
- d = diameter of coil, between wire centers, in centimeters;
- k = effective dielectric constant of spacer;
- n = number of coil turns per meter;
- w = over-all diameter of coil wire, in centimeters;
- A = transmission loss, in decibels per meter;
- C = capacitance, in farads per meter;
- L = inductance of coil, in henries per meter;
- R = resistance of cable, ohms per meter;
- T = time delay, microseconds per meter;
- Z = cable impedance, ohms.

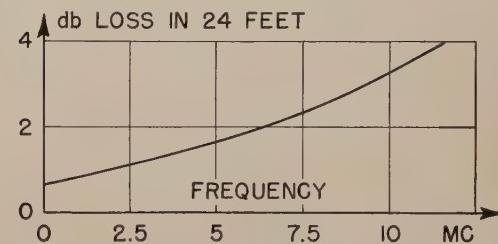


Fig. 4—Attenuation characteristic of experimental cable.

The inductance L of a continuously wound single-layer coil is given by (4)

$$L = 10^{-11} \pi^2 n^2 d^2 \text{ henries per meter.} \quad (4)$$

The capacitance C of a concentric cable is given by

$$C = \frac{24 \times 10^{-12} k}{\log_{10} a/b} \text{ farads per meter.} \quad (5)$$

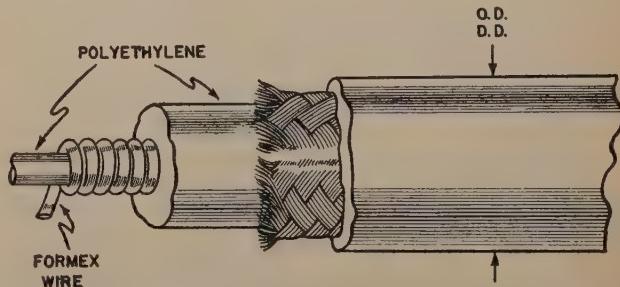


Fig. 5—Construction of manufactured cable.

From (1), (4), and (5), follows (6) for the impedance

$$Z = \sqrt{\frac{10^{-11} \pi^2 n^2 d^2 \log_{10} a/b}{24 \times 10^{-12} k}} = \frac{\pi n d}{\sqrt{2.4 k}} \sqrt{\log_{10} a/b}. \quad (6)$$

From (2), (4), and (5), follows (7) for the time delay

$$T = 10^6 \sqrt{\frac{24 \times 10^{-23} \pi^2 n^2 d^2 k}{\log_{10} a/b}} = \frac{10^{-5} \pi d n \sqrt{2.4 k}}{\sqrt{\log_{10} a/b}}. \quad (7)$$

If, with negligible error, the surface of the coiled inner

conductor is assumed to be a cylinder of the diameter b , then

$$b = d + w \quad (8)$$

and the core diameter is, evidently,

$$c = d - w. \quad (9)$$

From (6) and (7) it follows that the impedance Z rises, and the delay T decreases, with increased outer diameter a . The design of a cable, thus, should begin with a choice of the largest practicable outer diameter. For example, in order to fit into $\frac{3}{8}$ -inch fittings, the cable may have an outer diameter as large as 0.405 inch. Allowing for an average of 0.030-inch wall of a protecting jacket, and 0.016 inch for average thickness of the outer conductor, the outer diameter of the dielectric becomes 0.308 inch. The following computations are based on this and on a dielectric constant $k=2.25$, as found for a solid packing of polyethylene. Lowering of the effective dielectric constant by insertion of a loosely wound helical spacer is contemplated, improving both the impedance and the delay proportionally to $1/\sqrt{k}$.

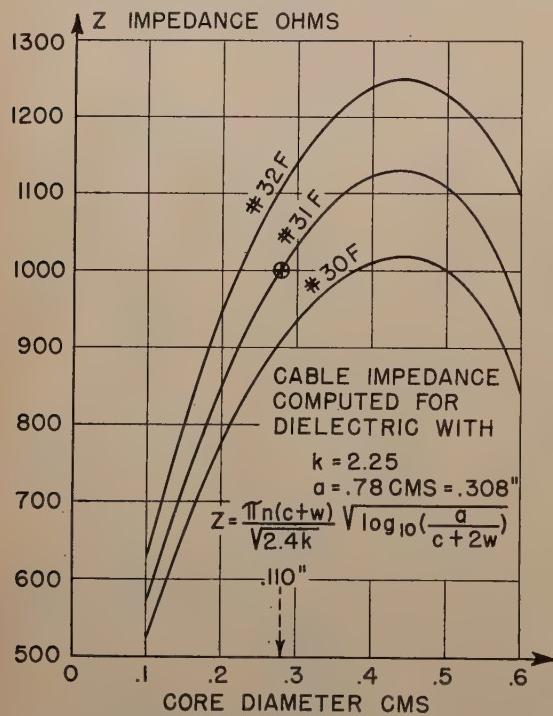


Fig. 6—Cable impedance as function of core diameter.

The impedance and the delay were computed from (6) and (7), on the basis of $a=0.308$ inch and $k=2.25$. They are plotted in Figs. 6 and 7, as a function of the core diameter c . Three curves are presented in each case, computed for coiled inner conductors close-wound with three different wire gauges. They are

- Formex copper wire No. 30F; $w=0.0108$ inch
- No. 31F; $w=0.0099$ inch
- No. 32F; $w=0.0089$ inch.

Fig. 6 shows that in all cases the impedance goes through a maximum, rising at first linearly with c in the numerator of (7), and then falling with $\sqrt{\log_{10} a/b}$. As can be seen, the maximum in each case is reached at

approximately the same value of c ; indeed, if w is negligible in comparison with d , so that $d \approx b$, then it can be shown that the maximum impedance is always reached for $a/d = \sqrt{e} = 1.65$; thus, for $a=0.308$ inch, $d \approx 0.187$ and $c \approx 0.45$ centimeter.

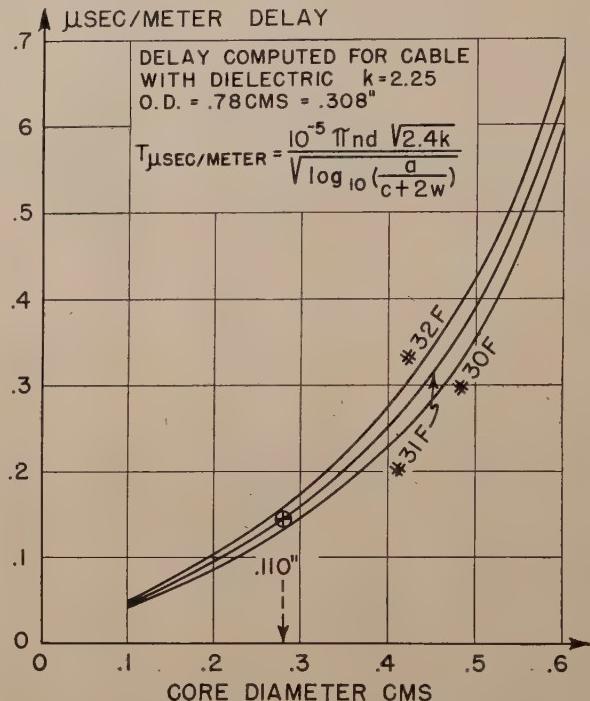


Fig. 7—Signal delay as function of core diameter.

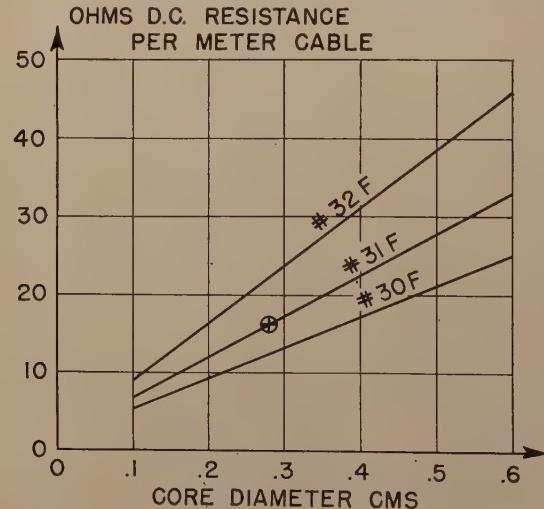


Fig. 8—Coil resistance as function of core diameter.

Judging from Fig. 6, a value of c at, or near, 0.45 centimeters would be a preferred choice yielding maximum impedance, besides maintaining it unchanged with large variations of the core diameter. However, the following other arguments militate against the choice:

1. As shown in Fig. 7, the delay per unit length of cable rises rapidly with the diameter of the core, due both to increased coil diameter (increased inductance) and to closer capacitor spacing (increased capacitance). The larger the delay, the further the spacing of echoes due to improper terminations.
2. The transmission loss¹ in the cable,

$$A_{ab} = \frac{4.35R}{Z} \quad (10)$$

is almost exclusively due to the resistance of R of the inner conductor, rising as plotted in Fig. 8 with the wire length, which in turn is proportional to the core diameter.

3. Parts of the magnetic field around the coiled inner conductor will cause eddy-current losses in the closed turn of the outer conductor, unless that conductor is either far enough away or braided of separately insulated wires.

A suitable compromise value for the core diameter, $c=0.28$ centimeter = 0.110 inch, is marked in Figs. 6, 7, and 8; it yields an impedance of 89 per cent of the optimum, but the corresponding delay is reduced to 49 per cent, the wire resistance to about 65 per cent, and the outer conductor has then a safe diameter 2.8 times that of the coil. It may be noted that the value of c so determined only depends on the value of a and k , but its choice is not affected if, for example, another impedance is desired. Fig. 6 shows that, in such cases, choice of a different wire gauge, wound on the same core diameter, is the only, and the most efficient, change required. The impedance rises by over 10 per cent each time the wire gauge is made one step higher (finer wire); the delay rises in the same proportion, but the series resistance R

rises by almost 35 per cent, and with it the transmission loss by about 20 per cent. At present, choice of American Wire Gauge No. 32 is thought to be a wise compromise, yielding 1000 ohms impedance with safe mechanical strength.

A cable based on this design is manufactured by the Federal Telegraph and Radio Corporation in Newark, New Jersey, as type RG-65/U. Its specifications are as follows:

Flexible plastic core, 0.110 inch ± 0.010 inch diameter.

Close-wound inner conductor, No. 32 F Formax.

Spacer of solid polyethylene extruded on this to an outer diameter, 0.285 inch ± 0.010 inch.

Outer conductor braided of bare copper wire, American Wire Gauge No. 33.

Jacket of vinylite, 0.030 inch.

Over-all diameter, 0.405 inch ± 0.010 inch.

Its electrical data are:

Impedance $Z=950 \pm 50$ ohms.

Capacitance $C=42$ micromicrofarads per foot.

Direct-current resistance = 7 ohms per foot.

Attenuation

5.5 decibels per 100 feet at 1 megacycle.

10.2 decibels per 100 feet at 3 megacycles.

21.5 decibels per 100 feet at 10 megacycles.

40 decibels per 100 feet at 30 megacycles.

Delay $T=0.042$ microsecond per foot at 5 megacycles.

A Study of Locking Phenomena in Oscillators*

ROBERT ADLER†, ASSOCIATE, I.R.E.

Summary—Impression of an external signal upon an oscillator of similar fundamental frequency affects both the instantaneous amplitude and instantaneous frequency. Using the assumption that time constants in the oscillator circuit are small compared to the length of one beat cycle, a differential equation is derived which gives the oscillator phase as a function of time. With the aid of this equation, the transient process of "pull-in" as well as the production of a distorted beat note are described in detail.

It is shown that the same equation serves to describe the motion of a pendulum suspended in a viscous fluid inside a rotating container. The whole range of locking phenomena is illustrated with the aid of this simple mechanical model.

I. INTRODUCTION

THE BEHAVIOR of a regenerative oscillator under the influence of an external signal has been treated by a number of authors. The case of synchronization by the external signal is of great practical interest; it has been applied to frequency-modulation receivers^{1,2} and carrier-communication systems,³ and formulas, as well as experimental data, have been given

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† Zenith Radio Corporation, Chicago, Illinois.

‡ C. W. Carnahan and H. P. Kalmus, "Synchronized oscillators as

for the conditions required for synchronization.⁴⁻⁸ The other case, arising when the external signal is not strong enough to effect synchronization, is of practical importance in beat-frequency oscillators. Here the tendency toward synchronization lowers the beat frequency and produces strong harmonic distortion of the beat note.⁴⁻⁸

It is the purpose of this paper to derive the rate of phase rotation of the oscillator voltage at a given instant from the phase and amplitude relations between the oscillator voltage and the external signal at that

frequency-modulation receiver limiters," *Electronics*, vol. 17, pp. 108-112; August, 1944.

² G. L. Beers, "A frequency-dividing locked-in oscillator frequency-modulation receiver," *PROC. I.R.E.*, vol. 32, pp. 730-738; *Elec. Eng.* December, 1944.

³ D. G. Tucker, "Carrier frequency synchronization," *Post Office Elec. Eng.*, vol. 33, pp. 75-81; July, 1940.

⁴ E. V. Appleton, "The automatic synchronization of triode oscillators," *Proc. Camb. Soc.*, vol. 21, pp. 231-248; 1922-1923.

⁵ D. G. Tucker, "The synchronization of oscillators," *Elec. Eng.*, vol. 15, pp. 412-418, March, 1943; pp. 457-461, April, 1943; vol. 16, pp. 26-30; June, 1943.

⁶ D. G. Tucker, "Forced oscillations in oscillator circuits," *Jour. I.E. (London)*, vol. 92, pp. 226-234; September, 1945.

⁷ S. Byard and W. H. Eccles, "The locked-in oscillator," *Wireless Eng.*, vol. 18, pp. 2-6; January, 1941.

⁸ H. G. Möller, "Über Störungsfreien Gleichstromempfang mit den Schwingaudion," *Jahr. für Draht. Telegr.*, vol. 17, pp. 256-287; April, 1921.

instant; in other words, to find a differential equation for the oscillator phase as a function of time. This equation must be expected to describe the case of synchronization where any transient disturbance vanishes in time, giving way to a steady state in which phase difference between oscillator and external signal is constant. It must also give frequency and wave form of the beat note, in case no synchronization occurs. To cover both cases, it must contain a parameter which decides whether or not the transient term will vanish in time, thus producing an equivalent to the criteria for synchronization derived by other methods. Finally, the equation must suggest a mechanical analogy simple enough to give a clear picture of what actually happens in an oscillator when an external signal is impressed upon it.

In the following analysis, it is assumed that the impressed signal and the free oscillation are of similar frequency. Locking effects at submultiple frequencies are analogous in many respects, but the analysis does not apply directly.

II. CONDITIONS FOR BANDWIDTH AND TIME CONSTANTS

In attempting to derive the rate of phase rotation at a given instant from no other data but phase and amplitude relations at that same instant, we assume implicitly that there are no aftereffects from different conditions which may have existed in the past. The value of such an assumption lies in the fairly simple analysis which it permits. But our experience with practical oscillators warns us that it may not always be justified. In this section we will study the requirements which an oscillator must meet so that our analysis may be applicable.

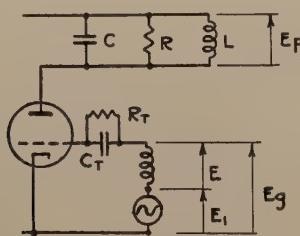


Fig. 1—Oscillator circuit.

If an oscillator is disturbed but not locked by an external signal, we observe a beat note—periodic variations of frequency and amplitude. If these variations are rapid, a sharply tuned circuit in the oscillator may not be able to respond instantaneously, or a capacitor may delay the automatic readjustment of a bias voltage. In either case, our assumption would be invalid. To validate it, we shall have to specify a minimum bandwidth for the tuned circuit and a maximum time constant for the biasing system. To establish these limits, let us study the circuit shown in Fig. 1, with the understanding that the impressed signal is not strong enough to cause locking. We will use the following symbols:

Angular frequencies:

ω_0 =free-running frequency

ω_1 =frequency of impressed signal

$\Delta\omega_0 = \omega_0 - \omega_1$ =“undisturbed” beat frequency

ω =instantaneous frequency of oscillation

$\Delta\omega = \omega - \omega_1$ =instantaneous beat frequency.

Voltages:

E_p =voltage across plate load

E =voltage induced in grid coil

E_i =voltage of impressed signal

E_g =resultant grid voltage

Q =figure of merit of plate load L , C , R .

If the oscillator were undisturbed, the only frequencies present⁹ would be ω_0 and ω_1 , producing a beat frequency $\Delta\omega_0$. Actually, a lower beat frequency is observed, so that the value of ω averaged over one complete beat cycle is shifted toward ω_1 . We cannot yet predict, however, how large the excursions of the momentary value of ω might be. We may think of ω as of a signal which is frequency modulated with the beat note $\Delta\omega$; this beat note is known to contain strong harmonics if the oscillator is almost locked, so that ω can be represented by a wide spectrum of frequencies extending to both sides of its average value.

If the plate circuit is to reproduce variations of ω without noticeable delay, each half of the pass band must be wide compared to the “undisturbed” beat frequency. For a single tuned circuit we can write

$$\frac{\omega_0}{2Q} \gg \Delta\omega_0. \quad (1)$$

Without reference to any specific type of circuit, we can say that the frequency of the external signal should be near the center of the pass band.

Up to this point, we have assumed that the circuit of Fig. 1 operates as a linear amplifier. But it is well known¹⁰ that some nonlinear element must be present to stabilize the amplitude of any self-excited oscillator. Curved tube characteristics may produce a nonlinear relation between grid voltage and plate current, distorting every individual cycle of oscillation (“instantaneous” nonlinearity); plate-current saturation is an example for this case. On the other hand, a nonlinear element may control the transconductance as the amplitude varies, thus acting like an automatic volume control; the relation between grid voltage and plate current may then remain linear over a period of many cycles. Oscillators stabilized by an inverse-feedback circuit containing an incandescent lamp provide perhaps the best example for this type. The combination of C_T and R_T in the circuit of Fig. 1 functions also as a controlling element of the automatic-volume-control type; at the same time, some nonlinearity of the “instantaneous” type will generally be present in this circuit.

We want the instantaneous amplitudes of the plate

⁹ “Frequency” always means the angular frequency.

¹⁰ B. van der Pol, “The nonlinear theory of electric oscillations,” Proc. I.R.E., vol. 22, pp. 1051–1086; September, 1934.

current and of the voltage E fed back to the grid to be the same as if the total grid voltage E_g at that instant had been stationary for some time; earlier amplitudes should have no noticeable aftereffects. How fast the amplitudes vary depends on the beat frequency. The amplitude control mechanism should, therefore, have a time constant which is short compared to one beat cycle.¹¹ (For the circuit of Fig. 1 this time constant would be of the order $T = C_T R_T$.) Since the shortest possible beat cycle corresponds to the "undisturbed" beat frequency $\Delta\omega_0$, we can write

$$T \ll \frac{1}{\Delta\omega_0}. \quad (2)$$

If the oscillator contains only amplitude limiting of the "instantaneous" type, this condition is inherently satisfied. An oscillator of the pure automatic-volume-control type will show the same locking and synchronizing effects as long as it fulfills¹² condition (2). But when the amplitude control mechanism acts too slow to accommodate the beat frequency, phenomena of an entirely different character appear. Such an oscillator would fall outside the scope of the mathematical analysis presented in the following, but its special characteristics merit brief discussion.

In an oscillator of the pure automatic-volume-control type, let us represent all elements outside the tuned circuit L , C , R by a negative admittance connected in parallel with L , C , R . The numerical value of this negative admittance is proportional to the gain in the oscillator tube. Over a long period of time, the automatic-volume-control mechanism will so adjust the gain that the negative admittance becomes numerically equal to the positive loss admittance of L , C , R . At this point the net loss vanishes and the prevailing amplitude is maintained indefinitely, as if the tuned circuit had infinite Q .

Now, let an external signal of slightly different frequency be superimposed upon this oscillation, so that the resulting amplitude varies periodically. Then if the automatic-volume-control mechanism acts so slowly that no substantial gain adjustments can be made within one beat cycle, that value of negative admittance which resulted in zero net loss will be retained. In other words, the system acts as if the Q of the plate circuit were still infinitely large. An external signal E_1 with a frequency very close to ω_0 will then produce a large near-resonant amplitude, increasing further the closer ω_1 approaches ω_0 . This magnified signal of frequency ω_1 , superimposed on the original signal of frequency ω_0 , which is still maintained, produces amplitude modulation of a percentage much greater than would correspond to the ratio E_1/E .

Evidently, similar effects could be observed if the tuned circuit had of itself a Q high enough to violate condition (1). This suggests an alternative way of stat-

ing that condition. The tuned circuit will "memorize" phase and amplitude for a period of the order T' , its "decay time." This period must be short compared to a beat cycle¹¹

$$T' \ll \frac{1}{\Delta\omega_0}. \quad (1a)$$

For a simple tuned circuit, $T' = (2Q/\omega_0)$ hence $(\omega_0/2Q) \gg \Delta\omega_0$ which is the same as (1).

If an oscillator fulfills both conditions (1) and (2), the amplitude modulation arising from a given signal E_1 is solely determined by the ratio E_1/E and by the shape of the amplitude-limiting or automatic-volume-control characteristic. Most oscillators operate in a fairly flat part of this characteristic, so that the amplitude actually varies less than in proportion to E_1/E . Keeping this in mind, we further assume a weak external signal

$$E_1 \ll E \quad (3)$$

so that the amplitude variations of E will also be small compared to E itself.

A surprisingly large number of practical cases meet all three conditions.

III. DERIVATION OF THE PHASE AS A FUNCTION OF TIME

Let Fig. 2 be a vector representation of the voltages in the grid circuit as they are found at a given instant.

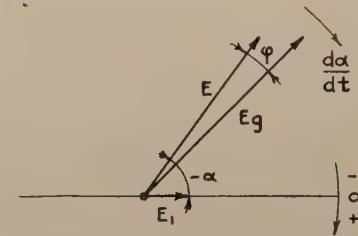


Fig. 2—Vector diagram of instantaneous voltages.

Furthermore, let E_1 be at rest with respect to our eyes; any vector at rest will therefore symbolize an angular frequency ω_1 , that of the external signal, and a vector rotating clockwise with an angular velocity $(d\alpha/dt)$ shall represent an angular frequency $\omega_1 + (d\alpha/dt)$, or angular beat frequency of

$$\Delta\omega = \frac{d\alpha}{dt} \quad (4)$$

relative to the external signal.

It is important to keep in mind that this vector diagram shows beat frequency and phase. Many high-frequency oscillations may occur during a small shift of the vectors. We call $(d\alpha/dt)$ the instantaneous angular beat frequency; we would count $(1/2\pi)(d\alpha/dt)$ beats per second if this speed of rotation were maintained. Actually, $(d\alpha/dt)$ may vary and a complete beat cycle may never be accomplished.

With no external signal impressed, E_g and E must coincide: the voltage E returned through the feedback

¹¹ $1/\Delta\omega_0$, or the time required for one radian of a beat cycle, is used in the following.

¹² For synchronization on a subharmonic of the impressed signal, nonlinearity of the "instantaneous" type is necessary.

circuit must have the same amplitude and phase as the voltage E_g applied to the grid. Those nonlinear elements which limit the oscillator amplitude will adjust the gain so that $|E| = |E_g|$; but the phase can only coincide at one frequency, the free-running frequency ω_0 . At any other frequency the plate load would introduce phase shift between E_g and E . Fig. 3 shows a typical curve of phase shift versus frequency for a single tuned circuit as assumed in Fig. 1. The amount of lead or lag of the voltage drop across such a circuit with respect to the current flowing through it is plotted. For our oscillator

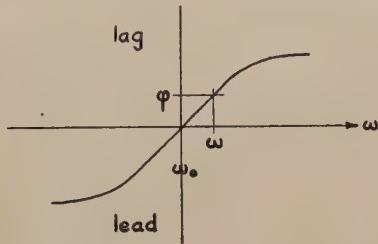


Fig. 3—Phase versus frequency for a simple tuned circuit.

circuit, we may take the curve to represent the lead or lag of E with respect to E_g as a function of frequency.

Let now an external voltage E_1 be introduced, and let Fig. 2 represent the voltage vectors at a given instant during the beat cycle. Evidently, the voltage E returned through the feedback circuit is now no longer in phase with the grid voltage E_g ; the diagram shows E lagging behind E_g by a phase angle ϕ .

No such lag could be produced if the oscillator were still operating at its free frequency ω_0 . We conclude that the frequency at this instant exceeds ω_0 by an amount which will produce a lag equal to ϕ in the plate circuit.

With $E_1 \ll E$ according to our third condition, inspection of Fig. 2 yields

$$\phi = \frac{E_1 \sin(-\alpha)}{E} = -\frac{E_1}{E} \sin \alpha. \quad (5)$$

The instantaneous frequency ω follows from Fig. 3. But our first condition implies that the pass band of the plate circuit is so wide that all frequencies are near its center. So we are using only a small central part of the ϕ versus ω curve which approaches a straight line with the slope

$$A = \frac{d\phi}{d\omega}. \quad (6)$$

Then, if ω_0 is the free frequency, the phase angle for another frequency ω close to it will be

$$\phi = A(\omega - \omega_0). \quad (7)$$

The instantaneous beat frequency $\Delta\omega$ is the difference between ω and the impressed frequency ω_1 . Setting again $\Delta\omega_0 = \omega_0 - \omega_1$, we have

$$\phi = A(\omega - \omega_0) = A[(\omega - \omega_1) - (\omega_0 - \omega_1)] = A[\Delta\omega - \Delta\omega_0]. \quad (8)$$

Now, substituting (5) on the left and (4) on the right, we find

$$-\frac{E_1}{E} \sin \alpha = A \left[\frac{d\alpha}{dt} - \Delta\omega_0 \right] \quad (9a)$$

and substituting

$$B = \frac{E_1}{E} \cdot \frac{1}{A}$$

we obtain

$$\frac{d\alpha}{dt} = -B \sin \alpha + \Delta\omega_0. \quad (9b)$$

Adding the impressed frequency ω_1 on both sides, we may also write

$$\omega = -B \sin \alpha + \omega_0. \quad (9c)$$

This means physically that the instantaneous frequency is shifted from the free-running frequency by an amount proportional to the sine of the phase angle existing at that instant between the oscillator and the impressed signal. The shift is also proportional to the impressed signal E_1 , but inversely proportional to the oscillator grid amplitude E and to the phase versus frequency slope A of the tuned system employed.

For a single tuned circuit, textbooks give

$$\tan \phi = 2Q \frac{\omega - \omega_0}{\omega_0} \quad (10)$$

and for small angles we can write

$$\phi = 2Q \frac{\omega - \omega_0}{\omega_0}. \quad (10a)$$

Hence, substituting into (6)

$$A = \frac{2Q}{\omega_0} \quad (10b)$$

and

$$B = \frac{E_1}{E} \frac{\omega_0}{2Q}. \quad (10c)$$

Equation (9b) reads, therefore, for a single tuned circuit,

$$\frac{d\alpha}{dt} = -\frac{E_1}{E} \frac{\omega_0}{2Q} \sin \alpha + \Delta\omega_0. \quad (11)$$

The possibility of a steady state is immediately apparent; $(d\alpha/dt)$ must then be zero, so that in the steady state

$$0 = -\frac{E_1}{E} \frac{\omega_0}{2Q} \sin \alpha + \Delta\omega_0 \quad (12a)$$

or

$$\sin \alpha = 2Q \frac{E}{E_1} \frac{\Delta\omega_0}{\omega_0}. \quad (12b)$$

This gives the stationary phase angle between oscillator and impressed signal. Since $\sin \alpha$ can only assume

values between +1 and -1, no steady state is possible if the right side of (12b) is outside this range. This gives the condition for synchronization

$$\left| 2Q \frac{E}{E_1} \cdot \frac{\Delta\omega_0}{\omega_0} \right| < 1 \quad (13a)$$

or

$$\frac{E_1}{E} > 2Q \left| \frac{\Delta\omega_0}{\omega_0} \right|. \quad (13b)$$

Because of its practical importance for receiver applications, another form of this condition shall be considered. E is the voltage which the oscillator (Fig. 1) produces across its grid coil; but if a locked oscillator is used to replace an amplifier, the voltage E_p across the plate circuit is the one that matters, since (E_p/E_1) represents the total gain. Now the tuned circuit is equivalent to a plate load $R_p = Q\sqrt{(L/C)}$, so that for a given transconductance g_m

$$E_p = E \cdot g_m \cdot Q \sqrt{\frac{L}{C}}.$$

Combining this with (13b), we obtain

$$\frac{E_p}{E_1} < \left| \frac{\omega_0}{2\Delta\omega_0} \right| \cdot g_m \sqrt{\frac{L}{C}}. \quad (13c)$$

It is interesting to note that Q , the only circuit constant entering into (13b) where the grid voltage E is of interest, cancels out in (13c) where the plate voltage E_p is determined.

For an oscillator which contains a plate load other than a simple tuned circuit, the condition for synchronization may be written

$$\frac{E_1}{E} > | A \Delta\omega_0 | \quad (13d)$$

whereby $A = (d\phi/d\omega)$ for the particular type of plate load.

IV. APPROXIMATION FOR THE PULL-IN PROCESS

Turning now to the transient solution of the differential equation (9b), we examine first the case $\Delta\omega_0 = 0$. This means that the free-running frequency equals that of the impressed signal and that locking will eventually occur for any combination of voltages and circuit constants as evidenced by all forms of (13).

The equation

$$\frac{d\alpha}{dt} = -B \sin \alpha \quad (14a)$$

shows what happens when the external signal E_1 is suddenly switched on with an initial lag α_1 behind the free-running oscillator. Equation (14a) is quite similar to

$$\frac{d\alpha}{dt} = -B\alpha \quad (14b)$$

and actually goes over into this form when α is small. Equation (14b) has the familiar solution

$$\alpha = \alpha_1 e^{-Bt} \quad (14c)$$

and this means physically that the oscillator phase "sinks" toward that of the impressed signal, first approximately, and later accurately as a capacitor discharges into a resistor. The speed of this process, according to (10c) which defines B , is proportional to the ratio of impressed voltage to oscillator voltage and to the bandwidth of the tuned circuit.

If the free-running frequency is not equal to that of the impressed signal, but close enough to permit locking for a given combination of constants according to (13), the manner in which the steady state is reached must still resemble a capacitor discharge. It is particularly worth noting that the final value α_∞ is always approached from one side in an aperiodic fashion. The accurate solution for this case will be given later.

V. PHENOMENA OUTSIDE THE LOCKING RANGE

To obtain a general solution giving α as a function of time, it is necessary to integrate (9b). We first substitute

$$K = \frac{\Delta\omega_0}{B} \quad (15a)$$

which means for a single tuned circuit

$$K = 2Q \frac{E}{E_1} \frac{\Delta\omega_0}{\omega_0}. \quad (15b)$$

By comparing with (13a) and (13d), we find that the condition for synchronization can now be written

$$| K | < 1. \quad (15c)$$

Substituting into (9b) we obtain

$$\frac{d\alpha}{dt} = -B(\sin \alpha - K). \quad (16)$$

Integration gives

$$\tan \frac{\alpha}{2} = \frac{1}{K} + \frac{\sqrt{K^2 - 1}}{K} \tan \frac{B(t - t_0)}{2} \sqrt{K^2 - 1} \quad (17a)$$

or

$$\alpha = 2 \tan^{-1} \left[\frac{1}{K} + \frac{\sqrt{K^2 - 1}}{K} \tan \frac{B(t - t_0)}{2} \sqrt{K^2 - 1} \right] \quad (17b)$$

wherein t_0 is an integration constant.

Let us now assume that the condition for synchronization is not fulfilled, so that $| K | > 1$. This makes $\sqrt{K^2 - 1}$ real. With continually increasing t , the term $[B(t - t_0)/2]\sqrt{K^2 - 1}$ will pass through $\pi/2$, $3\pi/2$, etc., and the tangent on the right side of (17a) will become $+\infty$, $-\infty$, etc. in succession; at these instants $\alpha/2$ must also be $\pi/2$, $3\pi/2$, etc., although it will assume values different from $[B(t - t_0)/2]\sqrt{K^2 - 1}$ during the intervals.

So, while $[B(t-t_0)/2]\sqrt{K^2-1}$ increases uniformly with time, $\alpha/2$ will grow at a periodically varying rate; but the total length of a period must be the same for both. The average angular beat frequency—the actual number of beats in 2π seconds—is therefore

$$\bar{\Delta\omega} = B\sqrt{K^2 - 1} \quad (18a)$$

or, substituting from (15a),

$$\bar{\Delta\omega} = \Delta\omega_0 \frac{\sqrt{K^2 - 1}}{K}. \quad (18b)$$

$\Delta\omega_0$ is that beat frequency which would appear if the oscillator maintained its free frequency; $\sqrt{K^2-1}/K$ approaches unity for large values of K , far from the point where locking occurs; but it drops toward zero when this point ($K=1$) is approached.

Fig. 4 shows a plot of the average beat frequency $\bar{\Delta\omega}$ versus the undisturbed beat frequency $\Delta\omega_0$ as computed from (18b).

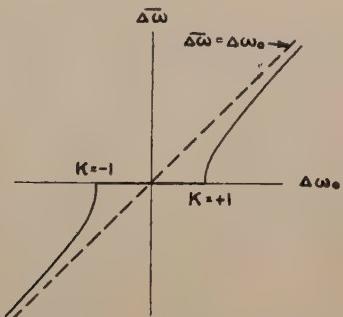


Fig. 4—Reduction of beat frequency due to locking.

In the intervals between the arguments $\pi/2$, $3\pi/2$, etc., the two angles in (17a) cannot be the same because of the factor $\sqrt{K^2-1}/K$ with which one tangent is multiplied, and the addition of $1/K$. For large values of K , $1/K$ vanishes and the factor approaches unity, so that the rate of increase of $\alpha/2$ with time will vary by a smaller percentage as the beat frequency increases; but (16) shows that $d\alpha/dt$ must still vary between $B(K-1)$ and $B(K+1)$. Now, $BK=\Delta\omega_0$, according to (15), and B represents the highest difference $\Delta\omega_{\max}$ for which locking can occur ($K=1$ for $B=\Delta\omega_0$). So the instantaneous beat frequency $\Delta\omega$ will vary periodically between $\Delta\omega_0-\Delta\omega_{\max}$ and $\Delta\omega_0+\Delta\omega_{\max}$ as long as $\Delta\omega_0$ exceeds $\Delta\omega_{\max}$.

$\Delta\omega_{\max}$ itself is determined by (13). It is

$$\Delta\omega_{\max} = \frac{\omega_0}{2Q} \frac{E_1}{E} \quad (19a)$$

or

$$\Delta\omega_{\max} = \frac{\omega_0}{2} \frac{E_1}{E_p} g_m \sqrt{\frac{L}{C}} \quad (19b)$$

for a single-tuned circuit, and

$$\Delta\omega_{\max} = \frac{1}{A} \cdot \frac{E_1}{E} \quad (19c)$$

for any type of plate load for which $A=d\phi/d\omega$.

If K is only slightly above unity, the factor $\sqrt{K^2-1}/K$ falls far below unity, and the phase angle between E_1 and E increases at an extremely nonuniform rate. Inspection of the vector diagram in Fig. 2 gives the resultant grid voltage $E_g=E-E_1 \cos \alpha$. To illustrate the wave form of the resultant beat note



Fig. 5—Wave form of beat note for $\cos \alpha(t)$.

the function $\cos \alpha(t)$ is plotted in Fig. 5. Operation very close to locking is assumed. Other wave forms are possible in beat-frequency oscillators where the beat note is produced in a separate detector; a constant phase shift may then be added to α on the way to the detector. Fig. 6 shows an example with a phase shift of $\pi/2$: the

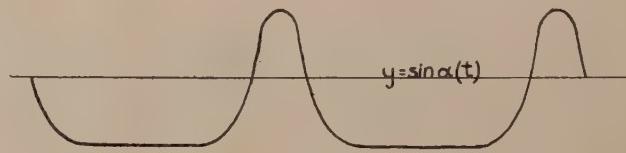


Fig. 6—Wave form of beat note for $\cos [\alpha(t) + \frac{\pi}{2}]$.

function plotted is $\cos [\alpha(t) + \pi/2]$ which equals $-\sin \alpha(t)$.

VI. ACCURATE ANALYSIS OF THE PULL-IN PROCESS

To make the discussion of (17a) complete, we may finally apply it to the case of an oscillator pulling into the locked condition, $|K| < 1$. The term $\sqrt{K^2-1}$ then becomes $j\sqrt{1-K^2}$. By use of the relation $\tanh x = -j \tan jx$, equation (17a) is transformed¹³ into

$$\tan \frac{\alpha}{2} = \frac{1}{K} - \frac{\sqrt{1-K^2}}{K} \tanh \frac{B(t-t_0)}{2} \sqrt{1-K^2}. \quad (20a)$$

The integration constant t_0 permits one to fit the equation to the initial phase difference α_1 , which exists when the external signal is switched on.

As t increases, the functions \tanh and \coth go asymptotically toward unity. The steady state must therefore be given by

$$\tan \frac{\alpha}{2(\infty)} = \frac{1 - \sqrt{1 - K^2}}{K}. \quad (20b)$$

Using (16) we identify K with $\sin \alpha_\infty$ for the steady state. Hence $\sqrt{1-K^2} = \cos \alpha_\infty$ and (20b) becomes $(1 - \cos \alpha_\infty)/\sin \alpha_\infty$, which is indeed equal to $\tan(\alpha_\infty/2)$ by a trigonometrical identity.

VII. A MECHANICAL MODEL

In conclusion, let us construct a mechanical model to

¹³ Equation (20a) holds for $\sin \alpha_1 > k$. Otherwise, substitute \coth for \tanh .

illustrate the processes which we have derived. To provide a full analogy, the model must follow the same differential equation (9b)

$$\frac{d\alpha}{dt} = -B \sin \alpha + \Delta\omega_0.$$

Let us forget $\Delta\omega_0$ for the moment. A pendulum in a viscous fluid would follow the remaining equation if α is taken to mean the angle between the pendulum and a vertical line. If we assume the viscosity of the fluid to be so great that we need not consider the inertia of the pendulum, the angular speed of the pendulum $d\alpha/dt$ is proportional to the force which causes it to move. We may shape the pendulum so that one unit of force will produce one unit of speed. Now, if B is the weight of the pendulum, the force acting to return it to its rest position will indeed be $-B \sin \alpha$.

To include the term $\Delta\omega_0$, we must add a constant force. We may also bring $\Delta\omega_0$ over to the left side of the equation; since $d\alpha/dt$ stands for angular speed, $-\Delta\omega_0$ on the left would mean a constant backward rotation of the pendulum with respect to the liquid. Constant forward rotation of the liquid with respect to the pendulum would produce the same force, and we choose this interpretation for our model shown in Fig. 7.

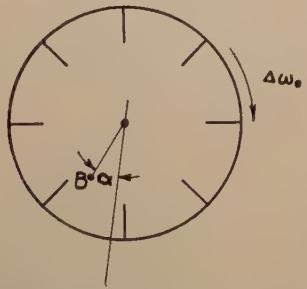


Fig. 7—Mechanical model: pendulum in a rotating container filled with viscous liquid.

The viscous liquid is enclosed in a drum rotating with an angular speed $\Delta\omega_0$. Again we assume that the viscosity of the liquid is so great that it will follow the rotation of the drum completely. Let us also assume that the rotation of the liquid is not noticeably affected by inserting the pendulum.

Remembering now that the vertical direction repre-

sents the phase of the impressed signal, while the position of the pendulum indicates the relative phase of the oscillator grid voltage, we can go through the whole range of phenomena by rotating the drum with various speeds, corresponding to the undisturbed beat frequencies $\Delta\omega_0$.

At low drum speed, the pendulum will come to rest at a definite angle α_∞ which will increase as the drum speed rises. If disturbed, the pendulum will "sink" back; it will never go past the rest position since inertia effects are absent.

If we lift the pendulum clockwise to any point below $\alpha_1 = \pi - \alpha_\infty$, it will come back counterclockwise; but if we lift it past this limit, or over to the right, it will return clockwise. This is the reason why there are two different transient solutions for (20a).

At a certain critical drum speed $\Delta\omega_{\max} = B$ the pendulum will stand horizontal; if the drum is further accelerated, it will "unlock" and begin to go around, moving fast on the right but very slow on the left and completing a much smaller number of revolutions than the liquid.

But as we increase the speed further, the fast whirling fluid takes the pendulum along, irrespective of the weight. The motion appears much more uniform, and the speed of the pendulum becomes nearly equal to that of the drum: the average beat frequency $\Delta\omega$ is approaching the undisturbed value $\Delta\omega_0$.

ACKNOWLEDGMENT

C. W. Carnahan and H. P. Kalmus, in the course of their work on locked oscillators for frequency-modulation receivers,¹ assembled a great deal of information regarding the behavior of such oscillators inside and outside the locking range. To study these phenomena further, they built a 1000-cycle oscillator which permitted direct observation of phase and amplitude variations on the oscilloscope. They investigated the influence of time constants and, among other effects mentioned in this paper, observed the large amplitude modulation which occurs when the time constant of the grid bias is large (case of "infinite Q" noted in Section II). Discussion of these experiments laid the groundwork for the analysis presented here, and the author gratefully acknowledges this important contribution.

Correspondence

Correspondence on both technical and nontechnical subjects from readers of the PROCEEDINGS OF THE I.R.E. AND WAVES AND ELECTRONS is invited subject to the following conditions: All rights are reserved by the Institute. Statements in letters are expressly understood to be the individual opinion of the writer, and endorsement or recognition by the I.R.E. is not implied by publication. All letters are to be submitted as typewritten, double-spaced, original copies. Any illustrations are to be submitted as inked drawings. Captions are to be supplied for all illustrations.

A Correction Formula for Voltmeter Loading

The writer has derived an equation which may be of interest to some of the members of The Institute of Radio Engineers. This equation corrects for the loading produced by current-operated (D'Arsonval) voltmeters. This derivation is believed to be original; however, it seems likely that such an expression may have been used in the past. If any members are acquainted with the following method of determining the true voltage between two terminals, it will be appreciated if they contact the writer giving the source of information.

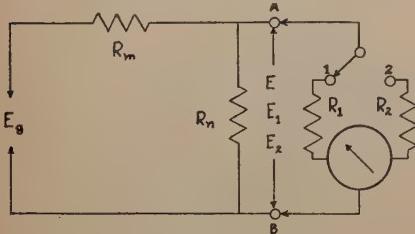


Fig. 1

Consider the basic circuit of Fig. 1. Let E = true voltage between terminals A and B with the voltmeter disconnected

E_1 = voltage measured on the highest range that will give an accurate reading

E_2 = voltage measured on the next range lower than used for E_1

E_s = source voltage of constant magnitude

R_1 = internal resistance of voltmeter when measuring E_1

R_2 = internal resistance of voltmeter when measuring E_2

S = ratio of the two scales used ($S = R_1/R_2$)

R_n = resistance across which output voltage is developed

R_m = series-dropping resistance that accounts for the differences among E , E_1 , and E_2 .

Simple circuit theory allows us to write

$$E = E_s \frac{R_n}{R_m + R_n}$$

then

$$E_1 = E_s \frac{R_1 R_n}{R_1 R_m + R_1 R_n + R_m R_n}$$

or

$$E_1 = E \frac{R_m + R_n}{R_m + R_n + (R_m R_n / R_1)} \quad (1)$$

likewise

$$E_2 = E \frac{R_m + R_n}{R_m + R_n + (R_m R_n / R_2)} \quad (2)$$

Substituting R_2 for R_1 in (1) and solving for E in both equations, we have

$$E = E_1 \frac{R_m + R_n + (R_m R_n / S R_2)}{R_m + R_n} \quad (3)$$

$$E = E_2 \frac{R_m + R_n + (R_m R_n / R_2)}{R_m + R_n} \quad (4)$$

Rearranging (3) and (4),

$$(R_m + R_n)(E - E_1) = E_1 \frac{R_m R_n}{S R_2} \quad (5)$$

$$(R_m + R_n)(E - E_2) = E_2 \frac{R_m R_n}{R_2} \quad (6)$$

Dividing (5) by (6),

$$S E_2(E - E_1) = E_1(E - E_2).$$

Thus,

$$E = \frac{(S - 1)E_1}{S - (E_1/E_2)} = \begin{cases} \text{true voltage be-} \\ \text{tween } A \text{ and } B \end{cases} \quad (7)$$

The equation, when written in this form, is particularly suited for slide-rule calculations. Furthermore, if the scale ratio S can be made equal to 2.0, then the equation simplifies to

$$E = \frac{E_1}{2 - (E_1/E_2)}.$$

Example: A voltmeter, when placed across two terminals, reads 105 volts on its 200-volt range. The voltmeter is switched to its 100-volt range and measures 70 volts.

$$E = \frac{105}{2 - (105/70)} = \frac{105}{2 - 1.5} = 210 \text{ volts.}$$

The correction factor given by (7) can be used for either alternating or direct-current circuits. The only restrictions are that the measurements be made in circuits that are linear and the voltmeter must be of the type in which the internal resistance is directly proportional to the selected range.

The question arises as to how well the equation will apply to circuits with vacuum tubes. Placing a current-operated voltmeter between the element of a tube and ground will lower the voltage on that element. It is important to know how the resistance of that element is affected when this happens. Experiment shows that the following is true: (1) When the tube is operated with fixed bias the element resistance changes radically with changes in element potential and the correction factor cannot be used. (2) When cathode bias is employed, the reduction in element voltage is accompanied by a reduction in current. Thus the resistance remains

substantially constant within the normal operating range of the tube and the equation may be used, but with reserve. The resulting error is usually less than 5 per cent, but errors as high as 14 per cent have been observed when making measurements in vacuum-tube circuits with a voltmeter sensitivity of 1000 ohms per volt. However, the error before correcting for voltmeter loading was in the order of 60 per cent for these cases.

In rare cases, the internal resistance of ammeters may cause a small error to exist between the measured current and the current that flows with the meter out of the

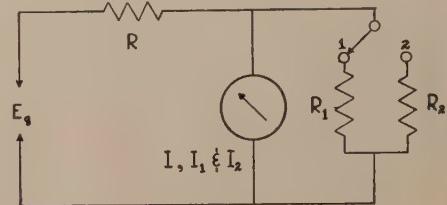


Fig. 2

circuit. It is possible to correct for this with an equation similar to equation (7). Consider the circuit shown in Fig. 2.

Let I = actual current that flows in the absence of the ammeter

I_1 = current measured on the highest range that will give an accurate reading

I_2 = current measured on the next range lower than used for I_1

E_s = source voltage of constant magnitude

R_1 = internal resistance of the ammeter when measuring I_1

R_2 = internal resistance of the ammeter when measuring I_2

R = circuit resistance

S = ratio of the two scales used. ($S = R_2/R_1$) (Note that for S to be greater than 1.0, the ratio must be the opposite to that used for voltmeters.)

Looking at the circuit, we can write

$$I = \frac{E}{R}$$

also

$$I_1 = I \left(\frac{1}{1 + (R_1/R)} \right) \quad (8)$$

and

$$I_2 = I \left(\frac{1}{1 + (R_2/R)} \right). \quad (9)$$

Substituting $S R_1$ for R_2 in (9) and solving for R in both equations,

$$R = \frac{R_1 I_1}{I - I_1} = \frac{S R_1 I_2}{I - I_2}. \quad (10)$$

Solving for I , we have

$$I = \frac{(S - 1)I_1}{S - (I_1/I_2)}. \quad (11)$$

RAYMOND E. LAFFERTY
513 Grand Ave.
Englewood, N. J.

Contributors to Proceedings of the I.R.E.



C. L. DOLPH

C. L. Dolph was born at Ann Arbor, Michigan, in 1918. He received the B.A. degree in mathematics from the University of Michigan in 1939, and the Ph.D. degree in mathematics from Princeton University in 1944. From 1940 to 1943 he was an instructor in mathematics at Princeton University. From 1943 to 1946 he was a member of the radio division of Naval Research Laboratory. He has recently joined the

technical staff of Bell Telephone Laboratories.

Dr. Dolph is a member of Phi Beta Kappa, Sigma Xi, and the American Mathematical Society.



Robert Adler (A'42) was born on December 4, 1913, at Vienna, Austria. He received the Ph.D. degree in physics in 1937, from the University of Vienna, and was assistant to a patent attorney in Vienna the following year. From 1939 to 1940, he worked for Scientific Acoustics, Ltd., London, England. After one year with Associated Research, Inc., in Chicago, he joined the research group of Zenith Radio Corporation in Chicago, and has remained with that organization to date.

During 1942 and 1943, Dr. Adler was engaged in work on high-frequency magnetostrictive oscillators. More recently, he was active in the vacuum-tube field through his development of the phasitron system of frequency modulation.



ROBERT ADLER



James F. Gordon (A'44) was born on April 10, 1912, at Helena, Montana. After graduation from high school he entered radio and refrigeration maintenance and installation work. From 1937 to 1941 he was engaged in the design and installation of electronic and allied equipment. In 1941 he joined the United States Signal Corps as civilian engineer and served as instructor in several Signal Corps schools. He joined the research staff of Bendix Radio in 1943. Since that time he has been active in the development of new electronic products.



JAMES F. GORDON



HEINZ E. KALLMANN

Heinz E. Kallmann (A'38-M'41-SM'43) was born on March 10, 1904, at Berlin, Germany. He received his Ph.D. degree from the University of Goettingen in 1929. From 1929 to 1934, Dr. Kallmann was a research engineer in the laboratories of the C. Lorenz A. G., and from 1934 to 1939 he was an engineer in the television research and design department of Electric and Musical Industries, Ltd. Hayes, England. Dr. Kallmann is now a consulting engineer in New York City. During 1940, he was a member of the New York Laboratory Staff of Scophony Television, Ltd. From 1943 to 1945 he was a member of the staff of the Radiation Laboratory, Massachusetts Institute of Technology.



Chicago Engineering



OFFICIAL PEOPLE

Left to right are W. O. Swinyard (A'37-M'39-SM'43), W. L. Everitt (A'25-M'29-F'38), and Cullen Moore (A'37-VA'39-SM'44).

APPROXIMATELY 500 guests registered for the Engineering Conference held by the Chicago Section of The Institute of Radio Engineers on February 9, 1946. Dr. William L. Everitt, junior past president of the I.R.E., delivered the opening address. Four technical sessions held during the day, a buffet luncheon, and the displays of 35 exhibitors were features of the meeting. The Conference was climaxed by the fourth annual banquet of the Chicago Section. Mr. Kenneth W. Jarvis presented a talk on "Those Things Which Make a Radio Engineer." Entertainment and dancing concluded the evening. The conference was a highly successful one, and the results were encouraging to the membership of the Chicago Section.

Summaries and titles of the technical papers presented follow.

DEFLECTION-TYPE HIGH-VOLTAGE SUPPLIES FOR TELEVISION RECEIVERS

MADISON CAWEIN

(Farnsworth Television and Radio Corporation, Ft. Wayne, Indiana)

The development of high-voltage power supplies in which the horizontal-deflection return pulse is rectified to provide a low-power source of direct current was discussed. The practical design of a high-voltage and

CONFERENCE COMMITTEE MEMBERS

Left to right are Karl Kramer (A'41-SM'45), W. O. Swinyard (A'37-M'39-SM'43), F. W. Schor (A'42-SM'45), A. W. Graf (A'26-VA'39-M'44-SM'45), R. T. Van Niman (A'44-M'44), L. E. Packard (M'41-SM'43), and R. E. Samuelson (SM'45).



deflection transformer was featured, and a brief discussion of deflection theory given.

INTERESTING APPLICATIONS OF INDUCTION AND DIELECTRIC HEATING

JOHN A. CALLANAN

(Illinois Tool Works, Chicago, Illinois)

THE LORAN NAVIGATION SYSTEM

DONALD G. FINK

(Electronics, New York, New York)

General principles of hyperbolic navigation and its application in the loran system were stressed, and airborne and shipborne equipment, as well as ground stations, were described.

ASPECTS OF FREQUENCY-MODULATION RECEIVER DESIGN

FRANK C. GOW

(Industry Service Division, RCA Laboratories, New York, New York)

The many often-little-recognized phases of frequency-modulation receiver design were reviewed. Attention was focused solely on considerations of general interest, such as oscillator stability, intermediate-frequency phase-shift characteristics and their relation to amplitude disturbances, radio-frequency tuning systems, the Seeley ratio detector, and automatic-frequency-control applications.

THE PRACTICAL ASPECTS OF INTERMODULATION AND APPLICATION TO DESIGN, TESTING, AND MAINTENANCE OF AUDIO SYSTEMS

JOHN K. HILLIARD

(Altec Lansing Corporation, Hollywood, California)

Intermodulation test equipment consisting of a signal generator and an intermodulation analyzer were described. The basic theory of the apparatus was discussed along with its application to the design and testing of amplifiers, disk and film recording, radio transmitters, and acoustic systems.

A GROUP OF NOTABLES

Left to right are D. E. Foster (A'26-M'37-SM'43), W. J. Polydoroff (M'24-SM'43), D. E. Noble (A'25-VA'39-SM'44), E. Wilby, Alfred Crossley (A'19-M'26-SM'43), R. H. Langley (A'12-M'16-F'29), and H. C. Luttgens (A'31-VA'39-SM'44).



Section Conference

RADIO APPLICATIONS FOR T3 SUBMINIATURE TUBES

WALTER R. JONES

(Radio Tube Division, Sylvania Electric Products, Inc., Emporium, Pennsylvania)

The design and the electrical characteristics of small tubes and their application in radio equipment were discussed.

RADIO-RECEIVER-RESPONSE TRENDS

HUGH S. KNOWLES

(Jensen Radio Manufacturing Company, Chicago, Illinois)

Several factors influencing over-all broadcast system response during the past two decades were discussed, and emphasis was placed on the electroacoustic elements in the system and their performance trends. Certain limitations imposed on frequency-modulation systems by acoustic considerations and electroacoustic components were also stressed.

DEVELOPMENTS IN ATOMIC ENERGY

ROBERT J. MOON

(Executive Committee, Atomic Scientists of Chicago, Chicago, Illinois)

The fundamental principles underlying release of nuclear energy and the design and construction of nuclear-energy devices, such as the pile, the atomic bomb, and the electromagnetic separator, were given. Problems arising as a result of the realization of nuclear energy were analyzed.

VT OR RADIO PROXIMITY FUZES

JOHN M. PEARCE

(Applied Physics Laboratory, Johns Hopkins University, Baltimore, Maryland)

AND

CLEDO BRUNETTI

(Project Engineering Section, Ordnance Development Division, National Bureau of Standards, Washington, D. C.)

The design features of battery- and generator-powered VT fuzes, insofar as security regulations permitted, were described.

SPEAKERS

Left to right are Madison Cawein (M'36-SM'43), J. P. Hilliard, F. C. Gow (A'44), and H. S. Knowles (A'25-VA'39-F'41).



A GROUP OF SPEAKERS

Left to right are Cledo Brunetti (A'37-VA'39), J. M. Pearce, D. G. Fink (A'35-VA'39-SM'45), and W. R. Jones (A'26-M'32-SM'42).

HUMAN RELATIONS IN ENGINEERING

WALTER D. KELSEY

(Dale Carnegie Institute, Chicago, Illinois)

How the engineer can obtain maximum efficiency from his assistants through co-operative effort and a thorough understanding of human nature was outlined.



The members of the various committees responsible for the conference are given below.

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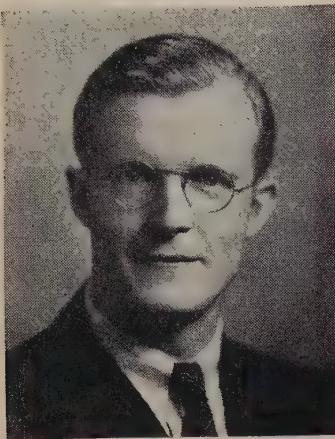
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Karl Kramer

J. A. Myers

H. S. Renne

I.R.E. People



J. D. SCHANTZ

J. D. SCHANTZ

The appointment of J. D. Schantz (A'35-SM'44) as assistant manager of the research department of Farnsworth Television and Radio Corporation, Ft. Wayne, Indiana, was recently announced by B. R. Cummings (A'18-M'20-SM'43), the firm's vice-president in charge of engineering. A graduate of Gettysburg College with a B.S. degree in electrical engineering, Mr. Schantz attended the United States Naval Academy for one and one-half years and Leland Stanford University for one year. He received his M.S. degree in engineering from the University of Michigan.

Mr. Schantz performed research in acoustics, sound recording, facsimile, and omnidirectional radio range at the RCA Victor Manufacturing Company's research department for two and one-half years. He came to Farnsworth in 1939 from Farnsworth Television, Inc., where he conducted research on circuits and television terminal equipment. Mr. Schantz is an Associate Member of Sigma Xi.

*

Abstracts and References

The Institute is pleased to announce the inauguration, in this issue of the Institute's journal, of comprehensive Abstracts and References of current engineering and scientific literature in the radio-and-electronic field. This material will be found beginning on page 407. Comments and suggestions of the readers concerning this will be of interest and help to the Editorial Department and should be addressed to The Institute of Radio Engineers, Inc.

Editorial Department
26 West 58th Street
New York 19, New York

*

VWOA SERVICE AWARDS

At the twenty-first Annual Dinner Cruise of the Veteran Wireless Operators Association, held on February 16, 1946, at the Hotel Astor, William J. McGonigle (A'45-M'45), president of the VWOA, presented Marconi Memorial Service Awards to The Institute of Radio Engineers and the American Radio Relay League.

Frederick B. Llewellyn (A'23-F'38), president of the I.R.E., accepted a plaque given "in significance of the conspicuous contributions of radio engineers to the successful prosecution of World War II" on behalf of the Institute. This award will occupy a prominent place in the new building of the Institute at Fifth Avenue at 79th Street.

George W. Bailey (A'38-VA'39), executive secretary of the I.R.E. and president of ARRL, accepted in the League's behalf a plaque given "in recognition of the part played by radio amateurs in the successful prosecution of World War II." This will be displayed at the League's national headquarters in West Hartford, Connecticut.



KARL KRAMER

KARL KRAMER

Karl Kramer (A'41-SM'45) has recently been named technical service engineer in the sales department of Jensen Radio Manufacturing Company, Chicago, Illinois. He received his B.E.E. degree from Ohio State University in 1931, and his graduate work, majoring in advanced communications, was performed at that institution where he received his M.Sc. degree in 1933.

Mr. Kramer joined Jensen in 1935 to serve as senior development engineer and applications engineer, and, in this capacity, he has been responsible for direct-radiator loudspeaker development and for the design and development of enclosures. Since his affiliation with the company, he has taken advanced mathematics and physics, with emphasis on subjects related to acoustics, at the University of Chicago and Illinois Institute of Technology.

A member of the Acoustic Society of America and the Radio Engineers Club of Chicago, Mr. Kramer presently serves on the executive committee of the Chicago Section of The Institute of Radio Engineers.



Major General H. C. Ingles looks on while Mr. William J. McGonigle presents VWOA Service Awards to Dr. Frederick B. Llewellyn (left) and Mr. George W. Bailey (right).



I.R.E. People

ADOLPH B. CHAMBERLAIN RECEIVES LEGION OF MERIT MEDAL

Adolph B. Chamberlain (A'27-M'30-F'42), chief engineer of the Columbia Broadcasting System, was awarded the Legion of Merit medal by Navy Secretary James Forrestal on February 27, 1946. The citation reads as follows: "For exceptionally meritorious conduct in the performance of outstanding services to the Government of the United States as Assistant Head of the Design Branch, Electronics Division, Bureau of Ships, from April to October, 1945. Exercising consistent ingenuity, patience, and judgment, Captain Chamberlain succeeded in breaking a tremendous design and production deadlock at a time when airborne radar equipment was urgently needed by the Fleet to combat enemy air action. By his expert professional ability and his tactful, persistent efforts in the fulfillment of an extremely difficult assignment, Captain Chamberlain was personally responsible for the expeditious completion and delivery of radar and countermeasures to the Fleet despite numerous technical problems, and his conduct throughout reflects great credit upon himself and the United States Naval Service."



DR. LLEWELLYN ATTENDS CONVENTION IN LONDON

At the invitation of the Institution of Electrical Engineers, Dr. F. B. Llewellyn, president of the Institute of Radio Engineers, was their guest at the Radiolocation Convention in London on March 26 to 29, 1946, which was the occasion for the presentation of a large number of technical papers on radar and on radio navigation. The Convention was opened by the Right Honorable John Wilmot, M.P., British Minister of Supply, whose remarks were followed by a paper on "The Evolution of Radiolocation" by Sir Robert Watson Watt. Dr. Llewellyn then brought greetings from The Institute of Radio Engineers. In his talk he dwelt upon the co-operation which existed during the war between engineers in England and America, and gave examples to show how joint effort along technical lines produced a more rapid development than would have been obtained by independent effort. He closed with a plea for a continuation of co-operative effort between engineers everywhere in order to further the causes of peace, and anticipated that the Institution of Electrical Engineers, in England, and The Institute of Radio Engineers, with headquarters in America, working together and with other organizations having similar aims and purposes, would provide the means through which this co-operative effort can be carried forward.

Following this opening session, on the evening of March 26, there was a dinner with the Council of the Institution of Electrical Engineers. During the ensuing three days of the Convention, Dr. Llewellyn had

a number of conferences with officers of the British Institution and members of its operating staff. The subjects discussed ranged all the way from questions of handling dues of I.R.E. members residing in England to the matters of exchanging abstracts of papers intended for publication at later dates and the organization and method of functioning of various types of technical committees.

Following the close of the Convention, Dr. Dunsheath, president of the Institution of Electrical Engineers made a presentation of an engraved silver tray to Dr. Llewellyn in behalf of the friends he had made in the Institution of Electrical Engineers.

Before his return to the United States, Dr. Llewellyn took the occasion to visit a number of the industrial and university research establishments in England, and was entertained both in Oxford and in Cambridge. On the evening preceding the Convention, he went on the air over the British Broadcasting Company with greetings from the I.R.E.



January, 1946, copies of the PROCEEDINGS OF THE I.R.E. AND WAVES AND ELECTRONS, in good condition, will be purchased by The Institute of Radio Engineers at 50 cents a copy.

DAVID SARNOFF

RECEIVES MEDAL FOR MERIT

The Medal for Merit was presented on March 18, 1946, to Brigadier General David Sarnoff (A'12-M'14-F'17), president of the Radio Corporation of America, by Major General H. C. Ingles, representing President Truman. The citation reads as follows: "David Sarnoff, for exceptionally meritorious conduct in the performance of outstanding services to the United States as president, Radio Corporation of America, from October, 1942, to March, 1944. Mr. Sarnoff placed the full resources of his company at the disposal of the Army whenever needed, regardless of the additional burden imposed upon his organization. He encouraged key personnel to enter the service, and at his direction, RCA engineers and technicians rendered special assistance on numerous complex communications problems. He fostered electronic advances which were adapted to military needs with highly beneficial results. The wholehearted spirit of co-operation which Mr. Sarnoff inculcated in his subordinates was of inestimable value to the war effort."

General Sarnoff was previously awarded the Legion of Merit medal in 1944 for "exceptional meritorious conduct in the performance of outstanding service" when he was on military service overseas.



Major General H. C. Ingles presents Medal for Merit to
Brigadier General David Sarnoff.

I.R.E. People

ARTHUR L. SAMUEL

ARTHUR L. SAMUEL

Arthur L. Samuel (A'24-SM'44-F'45) recently has been appointed professor of electrical engineering at the University of Illinois, where he will concern himself largely with research and development work on electron tubes, and the direction of graduate work in this field.

Dr. Samuel was born on December 5, 1901, in Emporia, Kansas. He received the A.B. degree in mathematics from the College of Emporia in 1923, and was enrolled in the co-operative course in electrical engineering at the Massachusetts Institute of Technology from 1923 to 1926, receiving the S.B. degree in 1925 and the S.M. degree in 1926. He has taken additional graduate work both at M.I.T. in electrical engineering and at Columbia University in physics, and recently was awarded the honorary degree of Sc.D. from the College of Emporia.

In addition to his work with the General Electric Company in connection with the co-operative course from M.I.T., Dr. Samuel was an employee of the General Electric Company prior to entering M.I.T. and again during the summer of 1927. Most of this time was spent in research and development work. After two years as an instructor in electrical engineering at M.I.T., he became a member of the technical staff at the Bell Telephone Laboratories where he has been continually engaged in research and development work on electron tubes. From 1928 to 1931 he was active in the development of gas rectifiers and thyratrons. Since 1931 his chief interest has been in the development of vacuum tubes for use at ultra-high frequencies. He is well known for his technical papers and patents in this field, having made contributions in the development of Barkhausen tubes, magnetrons, space-charge-controlled triodes and pentodes for ultra-high frequencies, velocity-variation oscillators and amplifiers, and transmit-receive gas switching tubes.

Dr. Samuel is a member of the American Physical Society, the American Association

(Continued on page 365)

SECTIONS**Chairman****Secretary**

R. N. Harmon 1920 South Rd. Mt. Washington Baltimore 9, Md.	ATLANTA September 20	M. S. Alexander 2289 Memorial Dr., S.E. Atlanta, Ga.
C. C. Harris Tropical Radio Telegraph Co. Box 584 Hingham, Mass.	BOSTON	F. W. Fischer 714 S. Beechfield Ave. Baltimore, Md.
J. M. Van Baalen 282 Orchard Dr. Buffalo 17, N. Y.	BUENOS AIRES	A. G. Bousquet General Radio Co. 275 Massachusetts Ave. Cambridge 39, Mass.
T. A. Hunter Collins Radio Co. 855-35 St., N.E. Cedar Rapids, Iowa	BUFFALO-NIAGARA September 18	Raymond Hastings Misiones 48 Buenos Aires, Argentina
Cullen Moore 327 Potomac Ave. Lombard, Ill.	CEDAR RAPIDS	H. W. Staderman 264 Loring Ave. Buffalo, N. Y.
J. D. Reid Box 67 Cincinnati 31, Ohio	CHICAGO September 20	R. S. Conrad Collins Radio Co. 855-35 St., N.E. Cedar Rapids, Iowa
R. A. Fox 2478 Queenston Rd. Cleveland Heights 18, Ohio	CINCINNATI June 18	D. G. Haines 4000 W. North Ave. Chicago 39, Ill.
R. C. Higgy 2032 Indianaola Ave. Columbus, Ohio	CLEVELAND September 26	P. J. Konkle 5524 Hamilton Ave. Cincinnati 24, Ohio
H. W. Sundius Southern New England Telephone Co. New Haven, Conn.	COLUMBUS July 12	Walter Widlar 1299 Bonnieview Ave. Lakewood 7, Ohio
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CLINTON B. DESOTO

On April 1, 1946, Clinton B. DeSoto (M'46) assumed the duties of technical editor of The Institute of Radio Engineers. Born in Ogilvie, Minnesota, in 1912, he attended the University of Wisconsin School of Journalism.

Mr. DeSoto became a licensed radio amateur in 1926, and in 1930 he joined the American Radio Relay League headquarters staff as assistant to the secretary. In 1936 he was appointed assistant secretary of the League, and in 1942 was transferred to the editorial staff as assistant editor of *QST*. Mr. DeSoto became executive editor of *QST* in 1943, and editor in 1944.

The author of a number of books and magazine articles dealing with radio topics, Mr. DeSoto handled the revision and production of the 1943, 1944, and 1945 editions of "The Radio Amateur's Handbook." He has also been associated with the development of radio remote-control systems for military and amateur applications. He served as secretary of the Connecticut Valley Section of The Institute of Radio Engineers from 1933 to 1936.

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(Continued from page 364)

for the Advancement of Science, and the American Institute of Electrical Engineers. He has long been active in the affairs of the Institute of Radio Engineers, and he received the best papers prize for 1937. He was chairman of the 1946 Electron-Tube Conference Committee and is at present a member of the Technical Committee on Electron Tubes, the Symbols Committee, and is chairman of the Subcommittee on Advanced Developments.

❖

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* Also chairman of its Subcommittee on Insulating Material Specifications for the Military Services.

Waves and Electrons Section



Joseph General
Secretary-Treasurer, Dayton Section, 1946

Joseph General was born in Waltham, Massachusetts, on March 12, 1910. He was graduated from the Rindge Technical School in 1928 and attended Tufts College Engineering School and was graduated with the degree of Bachelor of Science in electrical engineering in 1932.

He was associated with Dr. G. W. Kenrick in Kennelly-Heaviside layer investigations; the relation between radio-transmission path and magnetic-storm effects; and the location of tropical storms using Watson Watt cathode-ray direction-finding equipment at Tufts College and at RCA Communications, Riverhead, and Rio Piedras, Puerto Rico, from 1931 to 1937.

He has worked with the Massachusetts State Police on two-way radio communication, and for the past

six years has been engineer in charge of the radio and radar branch, Flight Test Division, Patterson Field, Ohio.

Mr. General is the recipient of a War Department Meritorious Award, signed by General H. H. Arnold, Commanding General, Army Air Forces, for services rendered to the Army Air Forces, and for his publication of a maintenance manual entitled "Maintenance of Signal Corps Aircraft Equipment."

He joined the Institute of Radio Engineers as an Associate in 1936 and was transferred to Member Grade in 1945. He has served as Secretary-Treasurer of the Dayton Section for the past two years and was one of the original group that founded the Dayton Section.

WAVES AND ELECTRONS has invited the Editors of journals in the radio-and-electronic domain to present to its readers their opinions and counsel which, being based on wide experience and detailed knowledge of the field, are of guiding value to engineers. There thus follows a guest editorial by the Editor of *Electrical Communication*.—The Editor.

The Engineer and Social Co-ordination

H. T. KOHLHAAS

This postwar "peacetime" world being greatly muddled, an editor is tempted to pose the question, "Why, instead of the world going round, does it not go ahead?" Briefly, I am convinced that what this country needs more than ever is neither a five-cent cigar, nor propaganda, but the comprehensive formulation and wide dissemination of blunt, unadulterated, basic facts and principles pertaining to our democracy and its functioning.

In London, in 1939, I was told that the Germans planned to train specialists in social co-ordination—individuals qualified to cope with over-all technical, political, and social conditions. In the United States of America this need perhaps also is gaining recognition—note the stress being placed by certain educators on training of our best minds in the social sciences. Einstein, it may be recalled, remarked some years ago that what this country needs most is leadership.

Too often political leaders are impelled to formulate policies after only superficial analysis and sell them to the people on an emotional basis. The consequence is that policies, laws, and commission decisions are too apt to be in conflict with the long-range interests of the country.

Many examples of the resulting lack of grasp of basic facts might be cited. Two should suffice: (1) During the war, perhaps properly, we referred to the Japanese "sneak" attack on Pearl Harbor. Does not history reveal plainly that a sudden attack somewhere was to be expected? (2) An item in the *New York Times* of January 25, 1946, "Some GI's Justify German Attack; Army Poll Shows Little Hostility," stated in part, "Authorities declared it (the survey) revealed an amazing lack of knowledge of the causes of the war, and that it appeared to indicate that the United States soldier in some cases had fallen for the propaganda of Germans echoing Joseph Goebbels." What else can one expect in this most complex age, when even election campaigns for high government office are conducted along emotional rather than factual lines?

Pre-1914, when a national crisis arose, the country looked to a prominent banker or industrialist for leadership, not always unbiased. Subsequently, high government officials assumed leadership, also not always unbiased, and now the labor leader is coming into greater prominence. But labor leadership too is not always wise from the viewpoint of the best interests of labor and the country.

Foreigners sometimes remark that we Americans are smug and not as good as we think we are. Heartsearching on the part of all of us without exception is urgently needed. Surely smugness or self-satisfaction is incompatible with progress.

People today, millions of them, crave enlightenment—unbiased, basic facts presented so that all can understand. A Committee or Board, if such were established, composed of outstanding individuals of the broadest viewpoint, could function as an educational or enlightening agency to acquaint the public with the fundamentals underlying many of our problems. Thereafter, solutions should become easier.

The Committee's basic thesis would be that this nation is fundamentally a democracy, devoted to the welfare of all, regardless of class, race, or creed. It would study basic social, industrial, agricultural, labor, educational, and governmental problems broadly and impartially, and point the way towards long-range constructive policies.

I am not advocating that The Institute take the lead in such an undertaking but rather that its members, and others, give consideration to implementing and participating in a movement in this direction. We Americans did an outstanding war job because we pulled together. We should be able to handle our peacetime job equally well, provided we formulate our objectives realistically, understand their implications, and adhere to them steadfastly.

One may confidently expect that the accomplishments of wartime technology will find many and useful applications in the arts of peace. Since World War II was pre-eminent among wars in its engineering achievements, it is natural to anticipate that its peacetime contributions may also be outstanding. Readers of the I.R.E. journal will accordingly find much of interest in the following guest editorial prepared by a scientific executive who is, as well, a Major General in the United States Signal Corps.—*The Editor.*

Commercial Applications of Wartime Science

G. L. VAN DEUSEN

With the easing of security restrictions the extent and importance of the contributions of science to warfare in radar, communications, and related electronic fields have been disclosed to the public. We can now foresee the early and widespread application of these new techniques to the needs of commerce and industry.

Radar will undoubtedly be of outstanding value as a navigational aid to air- and seacraft. Ocean-going vessels equipped with surface-search radar will have continuous, positive indication of all shipping in the vicinity, as well as an accurate picture of near-by land masses, icebergs, and other physical hazards. These devices will be especially helpful in fog and other conditions of poor visibility. Radar beams will supplement or replace fixed lights as aids to navigation.

The position-finding system known as loran (long-range navigation), developed during the War, may be extended for use wherever an extremely accurate, but simple, means of determining the position of a ship or airplane is required.

By the use of radar commercial aircraft will be able to read their absolute, or actual, altitude above the ground and to receive timely warning when approaching mountains or other obstacles. The application of such information must be so automatic as to relieve the pilot or navigator of responsibility for interpretation and decision. Crashes in mountainous regions by planes which are off their course in bad weather should no longer be chargeable to lack of proper information concerning ground hazards.

Long-range early-warning radar, similar to the "microwave" sets developed in the latter stage of the War, may be used to detect the presence of storm centers and to track their progress. This will be especially helpful in plotting storm movements over ocean areas.

"Radio relay" made possible the linking of higher military headquarters during landing operations and in periods of rapid movement such as followed the Normandy breakthrough. Here radar frequencies and transmitting techniques have been adapted to radiotelephony and -telegraphy, opening a new vista of multiple-channel communications in the ultra- and super-high-frequency bands. Improved equipment for automatic transmission and reception of radio-record traffic has also contributed to the integration of long-distance wire and radio systems, facilitating the establishment of world-wide communication networks.

Standardization of many components of electronic equipment was brought about during the War to simplify production and distribution problems, while giving proper weight to operating and maintenance conditions in the military service. These standards, subject to progressive revision, will now be available to industry as a guide wherever high quality is demanded.

Organized science, working in close co-operation with the technical services of the Army and Navy, achieved spectacular success in meeting the emergencies of World War II. There is now no reason why equally sensational advances should not be made in the corresponding activities of peace.

Some Broad Aspects of Specialization*

E. FINLEY CARTER†, FELLOW, I.R.E.

YOU MAY wonder why I have chosen this seemingly self-contradictory title for a discussion. How can breadth modify specialization? We think rightly of a specialist as one who has concentrated his efforts in the mastery of a chosen field for which he has developed certain outstanding talents. As such fields become broad, there is need for further specialization as has been evidenced over the years in other professions as well as in our own. Not so very long ago, a man specialized to become an engineer. Later, he had to choose whether he was to be a civil, a mechanical, or an electrical engineer. As the numbers of men engaged in these various branches grew, associations such as the American Society of Mechanical Engineers, the American Society of Civil Engineers, and the American Institute of Electrical Engineers were formed. It was only a little over thirty years ago that a few men with vision saw the trend of still further specialization and the Institute of Radio Engineers was organized. Even the most visionary of those men probably did not dream of two national conventions being held within the same week with three times as many registering for The Institute of Radio Engineers Winter Meeting as for the American Institute of Electrical Engineers Convention.

The fact that most of us who have engineering degrees received them in electrical engineering only serves to show that the trend toward specialization is so rapid that our basic training includes many things we soon discard and forget in order that we may concentrate our attention on our special interests and assignments. We accept the adage, "Jack of all trades; master of none," first as a warning of what might befall us if we do not become specialists, and then as a justification for letting our interest become so narrow as to exclude some that we can ill-afford to lose. Our profession becomes increasingly more complex as fields such as communications and industrial electronics broaden and become broken down into a great multiplicity of subdivisions which, in turn, are further divided so that a man can devote his full time to the study and mastery of a single phenomenon associated with the functioning of a vacuum tube, or in the study and application of a small portion of the frequency spectrum. Can you imagine the "International Society of Emission Engineers," or the "World Association for the Exploration of X Band"?

What we have seen in our profession can be witnessed in other professions, as well as in the world at large. I have heard my father say that his mother spun the cotton, wove the cloth, and made all the clothes for a big family, along with her other household duties. The

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† Sylvania Electric Products, Incorporated, New York, N. Y.

family was not wholly, but almost, independent of the world in general insofar as their daily needs were concerned, but they were dependent upon one another. To some fell the responsibility of sowing, cultivating, and harvesting; to others, the chores of preparing, applying, and maintaining. Life was rugged and required much sweat and hard work, if less suspense and frustration. Relatively, no doubt, life seemed as complex then as it does today, and even within the small group that composed a large family, there were difficulties experienced in understanding each other and in fully recognizing this interdependence.

Why is it that in our search for knowledge we have explored the infinite and the infinitesimal—we can predict the courses of stars and planets in their orbits so accurately as to set the time and place of an eclipse a hundred years from now, or with the building blocks of the universe can construct elements not previously found in nature—and yet we still seem, to be unable to answer the simple question asked by Cain, "Am I my brother's keeper?" We have learned to understand extremely complex mathematical equations and to make intricate and complex mechanisms whose performance is so easily predictable and whose operation is so simple that they are made to serve millions. But what have we done or what are we doing to understand the users of our creations?

I have been giving a great deal of thought recently to world events and have been wondering just why we have run afoul of many of these disturbances we have been seeing about us—seeking, as it were, the missing ingredient, the common solvent, or better, perhaps, the binder so sorely needed to hold civilization together harmoniously. I am convinced that this is a problem that may respond to the curious, analytical, and logical approach used by the engineer and scientist in solving other problems which, at least, at the first blush, seemed far more difficult of solution. I am likewise convinced that if enough engineers could get interested in a problem of this sort to make it a topic of general discussion and argument as free from prejudice and bias as some of our technical discussions, the results would be surprising. Let's start now on one facet of this problem. There are many, but let us consider the question of specialization and its part in the social picture.

Are our social problems today the result of overspecialization? Something seems wrong when 3500 tugboat operators can, within a week, paralyze the whole city of New York, or when a similarly small number of utility operators can tie up a city like Pittsburgh. What have we gained by making life so complex? Have we as individuals been short-sighted, or have we become narrow because we have concentrated our efforts on the

development of only a few talents? Wouldn't we be happier if we were more self-sufficient and less dependent upon people whom we do not know and have never seen? These questions are academic, for we are faced with the facts as they are; yet, they may help to stimulate sound thinking relative to what, if anything, we are going to do about it.

What should we do about it? Let us be logical and not overemotional as we explore this question. How are we going to recoup the security that we have lost through our specialization? Should we do as we find many others doing and form monopolies of our specialties so as to give us strong trading positions? In that way, we can at least make it hard on the other fellow if we don't get our just due. He will have to deliver, or else. That is, if he can deliver. If he can't, we all suffer—or do we all suffer anyway? Can there be economic gain by destroying wealth or by refusing to create it? Can we build a better society by refusing co-operation or by giving it?

I am afraid that a logical analysis of this problem would not yield the form of solution so generally tried. We do not offset the narrowness associated with specialization by a further withdrawal from society, nor do we enlist the aid and understanding of others through isolation. We may inflate our egos by criticizing those we do not understand, but we do not improve our stature by so doing, nor do we help others to understand us by being overly sensitive to and resentful of their criticism.

There can be little doubt but that specialization has brought with it many material blessings. Without it, who would be able to own a modern motor car or radio or television set, and if he owned it, what would he do with it? Our problem is not one of overspecialization; it is one of having failed to see some of the broader aspects of specialization, for corollary to specialization is understanding and co-operation within the complete social structure. There is no stronger team on the gridiron or in a business than a truly complementary group of individuals, each with his own particular talents. Let them pool this interest for the common good and they make a winning team; but let them become prima donnas, each seeking individual glory, and at best, it is a sad mess. Why does human society refuse to see that which should be so obvious? Why do so many individual members of society refuse to learn by experience? A newspaper survey, made some time ago, made the startling disclosure that only 5 per cent of the people think. Ten per cent think they think, and 85 per cent want someone else to do their thinking for them. I am convinced that among engineers, the percentage of those who think is much higher than 5 per cent. Because of this, I sincerely feel that as individuals, as well as an association of engineers, we can make a real contribution to the solution of our social ills by complementing our specialized talents with a sincere interest in the welfare of our fellow men. That interest can be the common binder which will weld humanity harmoniously together, for through it we shall learn to harness invisible,

yet nevertheless real, forces such as understanding, confidence, faith, love, and tolerance just as we have those of electricity, gravity, and magnetism in the realm of the physical sciences. We do not fear that which we understand, nor those whom we truly know. Self-confidence is essential to a sense of security, and confidence in others gives strength to that much-to-be-desired feeling. Faith in oneself, in others, and in a worthy cause is a force whose power we should recognize and upon which we should capitalize. Similarly, participation is the healthy psychological prescription to develop the whole man who, in turn, tends to find the greater success in his specialized work. Tolerance and a love of one's fellow man has a binding power that, if applied, would hold the world together in a unity strong enough to negate those divisive forces which thrust themselves so rudely upon us today. With this unity, a state of balance could be established that would permit the full blooming forth of those great constructive forces locked within man only by his ignorance of himself.

The house referred to in the adage, "A house divided against itself cannot stand," has now become the world. Scientists and engineers, more than any other group, have brought this about, and among the leaders in this group have been radio and communication engineers. We have worked hard to make it possible for any man's voice to reach the ears of all others. I think it should concern us whether the facilities making this possible are used to disseminate truth and understanding, or whether they are used to sow suspicion or to propagate lies and misunderstanding.

I do not want to oversimplify the social problems that are before us today. On the other hand, I am afraid there are many capable of making real contributions in this field who are not doing so because they feel the problem is too complex, or is beyond their control. Let me remind those who entertain such thoughts that before they were able to understand alternating currents and resonant phenomena, they first learned a few principles about direct current, then mastered Ohm's Law, after which they continued until they were able to observe new principles and apply them effectively.

There is an Ohm's law for our social relationships. There are resistances to overcome, potential required to overcome them, and currents that can be put into action as these resistances are overcome. There are also inductive and capacitive components in human society; each of you has encountered leading and lagging reactances. When we start to deal in human emotions, we get into resonant phenomena which are seemingly more complex and less predictable than those we have encountered in the field of radio engineering, but perhaps they would not be actually so if they were approached as analytically and as logically as we approach the problems within our special fields.

I am not urging anyone to shift from his chosen field of, let us say, radio engineering to that of psychology, even though by so doing he may carry over certain

techniques which would help him in his new field. What I am urging is that, along with our specialization, we develop broad interests which will not only help us to realize our interdependence, but will also awaken us to our social responsibilities and to a desire for a still broader understanding of the one science in which we should all want to specialize; namely, the science of living.

It is important for us to remember that, though we have set ourselves apart as members of a specialized profession, we continue as members of the great brotherhood of humanity. We still bear on our shoulders the heavy responsibilities that such membership carries with it.

First, of course, nearly all of us have inescapable duties as members or heads of families. Those who are parents share in the vitally important task of passing on to the next generation not only love, but the high points of the knowledge of life that we have gained in our own experience. Too often, we have seen the examples of men who are successful in business but low in competence as parents. This has been one of the basic causes of the commonly accepted tradition of "shirtsleeves to shirtsleeves in three generations."

Modern professional and business life takes us away from our homes, so that special effort may be required. Here science and production have made one contribution through the development of the five-day week, which permits us two full days for relaxation and close, personal contact with those in whom we have the most immediate interest.

I think it is in order to mention here that many of us are also members, albeit perhaps not so active as we might be, of some church group. Clearly, many of our ills in the world today can be solved only with a resurgence of spiritual morale and re-emphasis on the brotherhood of man and the age-old principles of successful living together.

The art of living together is also controlled in large measure by our methods of government and the men whom we select to govern. A third nonspecialized responsibility of each of us, therefore, becomes that of the responsibility of the citizen. Under our American form

of government, our political structure rises from the people. In Revolutionary days, only a relatively small proportion held the franchise. These tended to be those who were the more wealthy or more able. As the franchise has been extended to include today, at least in theory, almost the entire adult population, those who are gifted with exceptional ability or have had unusual educational, professional or business opportunities, therefore have the increasing responsibility of making their full contribution to the political life of our country. For them to withdraw from politics means to leave one of the most vital functions of our people in the hands of less-competent individuals with results that are often far too evident.

We need not be discouraged by the extent of the problem of being what might be called "all-around citizens." There are more than enough examples in our history and in current life today of men who have been outstanding in their professional attainments and who have maintained the same high level of excellence in their contributions to family, religious, and civic life. Indeed, the members of the group are particularly fortunate. We should be able to bring a scientific viewpoint tempered in the crucible of years of difficult work and scientific study to the solution of our problems. By the development of greater understanding and love for our fellows, we can help to make still more effective our personal contributions within our own groups. The impartial, truth-seeking approach of the engineer can be made into a tool of great value.

Each of us has an opportunity of unlimited research in this field. Each has an ever-present laboratory in which to experiment within himself. An earnest study of our behavior patterns and reactions to outside stimuli, followed by an objective application of the findings to our relationships with others, should enable us to make real contributions to the solutions of many common problems.

In closing, I would like to leave with you the challenge to utilize these facilities for observation and analysis of human reactions to the utmost, in order that you may make your specialized efforts a part of a broad plan of living from which you and all society will benefit.

Television Equipment for Guided Missiles*

CHARLES J. MARSHALL†, SENIOR MEMBER, I.R.E., AND
LEONHARD KATZ‡, MEMBER, I.R.E.

Summary—A brief history of the technical problems associated with the development of compact airborne television equipment is outlined. The system provides resolution, linearity, and stability which approaches that obtained from broadcast equipment. Technical difficulties which arose after the completion of the equipment design are described. The final solution of these and other problems resulting from its installation in guided missiles are discussed. Photographs taken from the receiver screen during experimental flights are shown.

INTRODUCTION

WITH THE rapid growth of the electronic art, during the latter part of the past decade, there appeared a definite possibility of utilizing television equipment in "suicide-type" airborne missiles in order to achieve high accuracy. Consequently, a project was established by the Army Air Forces for the development of television equipment for use in guided missiles of the direct-controlled type. It became the task of the Signal Corps Aircraft Radio Laboratory to develop equipment to meet these needs.

As a result of a development project involving television for another application, the RCA-Victor Division of RCA redesigned their portable equipment as an experimental model¹ called "jeep," for the preliminary tests.

Fig. 1 illustrates the essential airborne equipment, whose installed weight, including cables, antenna, brackets, etc., was 340 pounds. Its power demand from the airplane power supply was 45 amperes at 28.5 volts. During the course of the execution of this engineering problem, thought quite naturally evolved around the use of television for guided missiles. Sufficient interest was shown by the military authorities and the result was the construction of an experimental model which was called "jeepette" by the RCA engineers because of its ancestry.

Numerous flight tests at Wright Field with the "jeep" design had shown that compact, lightweight television equipment could be developed and used in aircraft. The problem of multiple paths of the radio-frequency energy from the transmitter to the receiver did not appear as a serious difficulty and neither did the somewhat lower than broadcast quality of the received picture. Since immediate application of the equipment was deemed advisable, development work on the "jeepette" was

pushed. During April, 1941, tests were conducted with this equipment installed in a B-18A airplane; however, without a radio link. It was necessary to determine the practicability of television as an adjunct to radio remote-control equipment for guided missiles. The camera was located in the nose of the airplane on the bombsight mount, while the monitor was located in the "blacked-out" rear compartment. From an altitude of 5000 feet and at a distance of five miles, it was possible to guide the plane on a collision course by means of observing the television monitor and calling course corrections to the pilot of the airplane over the interphone system. The result of these tests was the establishment of a development contract with the RCA-Victor Division of the Radio Corporation of America.

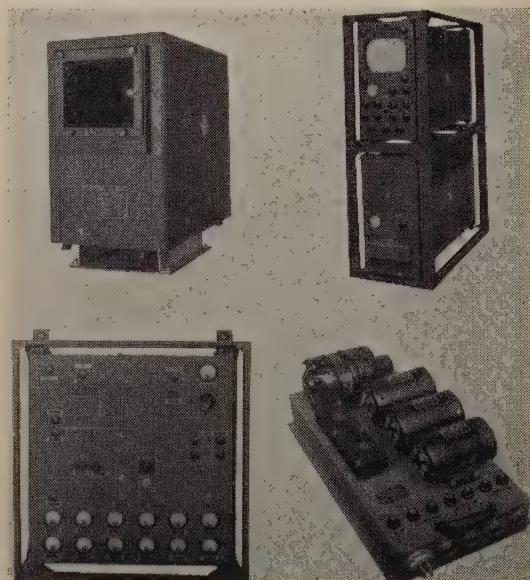


Fig. 1—625-line airborne television transmitting equipment known as "jeep." Upper left, camera; upper right, camera control and auxiliary units; lower left, radio transmitter; and lower right, dynamotor power supply.

Small size and weight immediately dictated that compromise television system standards must prevail. As a result of an analysis of the problem, it was decided to adhere to commercial or broadcast standards as much as possible. The following compromise standards were adopted at that time:

- (1) Forty frames per second.
- (2) 350 lines per frame.
- (3) Sequential scanning.
- (4) Video bandwidth of 4.5 megacycles.
- (5) Vertical polarization of radiated signal.
- (6) No direct-current transmission.
- (7) Omission of equalizing pulses.
- (8) Omission of serration of vertical-synchronizing pulse.

* Decimal classification: R583 X R570.4. Original manuscript received by the Institute, February 4, 1946. Presented, New York Section, New York, N. Y., March 6, 1946; Cincinnati Section, Cincinnati, Ohio, March 19, 1946; Dayton Section, Dayton, Ohio, April 18, 1946; Rochester Section, Rochester, N. Y., April 11, 1946; and Indianapolis Section, Indianapolis, Ind., April 26, 1946.

† Wright Field, Dayton, Ohio.

‡ Formerly, Wright Field, Dayton, Ohio; now, Raytheon Manufacturing Company, Waltham, Mass.

¹ G. L. Beers, O. H. Schade, and R. E. Shelby, "The RCA portable television pickup equipment," Proc. I.R.E., vol. 28, pp. 450-458; October, 1940.

(9) Synchronizing signal equal to approximately 35 per cent of carrier.

(10) Double-sideband transmission.

(11) Wider than Radio Manufacturers Association standard vertical-blanking and synchronizing pulses.

(12) Wider than Radio Manufacturers Association standard horizontal-blanking and synchronizing pulses.

The military standards were chosen after consideration was given to the size, weight, power demand, circuit complexity, resolution, and linearity interrelationships. It must be remembered that the tube complement was "frozen" in 1942 and at that time miniature tubes were not available. There are many technical papers which outline the considerations involved in choosing television standards.²⁻¹¹

During the course of this development program, the possibilities of types of camera pickup tubes, other than the iconoscope, appeared worthwhile of investigation. In particular, a development model of an image-dissector camera and several cameras using pickup tubes having low-velocity scanning (such as "orthicon" and similar types) were tested. These tubes, however, were found to have little or no advantage over the iconoscope, and for military reasons were found to be inferior.

DEVELOPMENT OF 100-MEGACYCLE EQUIPMENT

In the design of the first small television system, known as SCR-549-T1 and SCR-550-T1, the previously stated characteristics were embodied. It will be apparent from Fig. 2 that a considerable reduction in size and



Fig. 2—Radio transmitting equipment SCR-549-T1. Left to right: transmitter monitor, dynamotor power supply, 100-megacycle antenna, 7-cell lead-acid storage battery, and camera-transmitter.

² E. W. Engstrom, "Television image characteristics," *PROC. I.R.E.*, vol. 21, pp. 1631-1650; December, 1933.

³ E. W. Engstrom, "A study of television image characteristics," *PROC. I.R.E.*, vol. 22, pp. 295-310; April, 1935.

⁴ R. D. Kell, A. V. Bedford, and M. A. Trainer, "Scanning sequence and repetition rate of television images," *PROC. I.R.E.*, vol. 24, pp. 559-576; April, 1936.

⁵ V. K. Zworykin, "Iconoscopes and kinescopes in television," *RCA Rev.*, vol. 1, pp. 60-84; July, 1936.

⁶ S. W. Seely and C. N. Kimball, "Analysis and design of video amplifiers," *RCA Rev.*, vol. 2, pp. 171-183; October, 1937.

⁷ Albert Preisman, "Some notes on video amplifier design," *RCA Rev.*, vol. 2, pp. 421-432; April, 1938.

⁸ A. V. Bedford, "A figure of merit for television performance," *RCA Rev.*, vol. 3, pp. 36-44; July, 1938.

⁹ S. W. Seely and C. N. Kimball, "Analysis and design of video amplifiers," *RCA Rev.*, vol. 3, pp. 290-308; January, 1939.

¹⁰ R. D. Kell, A. V. Bedford, and G. L. Fredendall, "A determination of optimum number of lines in a television system," *RCA Rev.*, vol. 5, pp. 8-30; July, 1940.

¹¹ D. E. Foster and J. A. Rankin, "Video output systems," *RCA Rev.*, vol. 5, pp. 409-438; April, 1941.

weight has been effected over that of the "jeep." The total weight of the transmitting equipment, installed in an airplane, was approximately 60 pounds, less monitor unit and 14-volt 7-cell storage battery, which weighed 20 and 37 pounds, respectively. As to performance, little difference between the two systems could be noticed, although the "jeep" operated at 20 frames, 40 fields and 625 lines, interlaced scanning. The technical problems were too numerous at that time so that interlacing did not appear as a practical solution for the scanning system because "pairing" was generally observed during most airborne operations.

Reference is made to the block diagram, Fig. 3, where

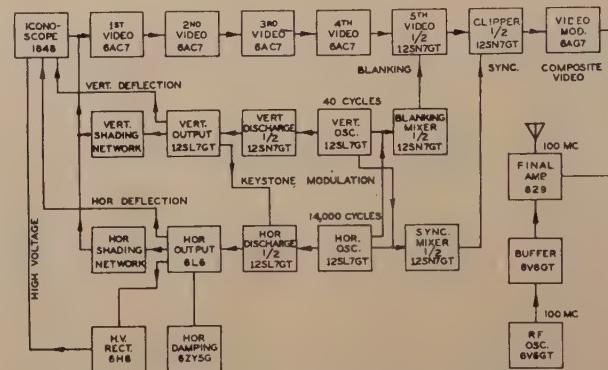


Fig. 3—Functional block diagram of 100-megacycle camera-transmitter.

the synchronizing generator and shaping equipment customarily used in broadcasting studios have been replaced by three dual-triode vacuum tubes and associated circuits. This simplification was accomplished at the expense of a lower number of scanning lines, lack of interlacing, higher blanking intervals, lower synchronizing stability, but with reasonably good picture quality. The usual iconoscope deflection system has been replaced with just five vacuum tubes including their circuits. In addition, these few tubes perform keystone, shading, and high-voltage power-supply functions. The video amplifier is somewhat simplified by combining the iconoscope with the entire video amplifier. The transmitter occupies a small compartment in the rear of the camera-transmitter unit. A power output of approximately 15 watts at 100 megacycles is provided. The 6V6GT modulator is capable of providing 100 per cent modulation with a normal scene on the iconoscope mosaic.

This early equipment was capable of operating with as low an illumination as 200 foot-candles on a normal contrast scene; however, bias lighting was not used. The lens used was a Bausch and Lomb Tessar with a focal length of 8½ inches and $f=3.5$. An RCA "Magicote" lens coating was used on the optical surfaces.

The horizontal- and vertical-timing pulses are generated in their respective multivibrator-type oscillators and are then coupled into a blanking mixer-amplifier. The composite blanking signal is then mixed with the

video signal in the plate circuit of the fifth video stage. The synchronizing signals are derived from the same oscillators and are mixed in an amplifier whose output is applied to the cathode of the cathode follower-clipper; thus synchronizing, blanking, and video have been combined to form a composite video signal which is coupled to the video amplifier and modulator of the transmitter section by means of a short length of coaxial cable. The video and synchronizing output signals for the transmitter monitor is also derived from the cathode-follower output terminal.

For deflection of the iconoscope beam, the horizontal and vertical frequency pulses are fed into discharge tubes and, thus, saw-tooth voltage waves are derived for use in driving the respective output tubes through coupling transformers to the deflection yoke. Output voltage from the vertical-deflection tube is used as the plate-voltage supply for the horizontal-discharge tube. This simple circuit provides excellent keystone modulation of the horizontal saw-tooth deflection voltage.

By means of an additional winding on the horizontal output transformer, high-voltage pulses are derived

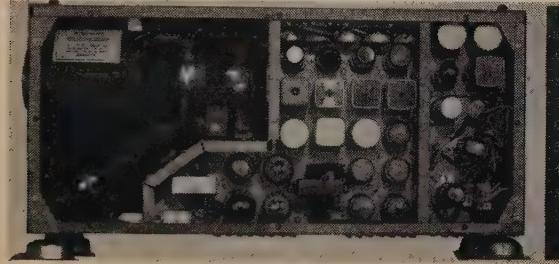


Fig. 4—Interior view of camera-transmitter of SCR-549-T2. All tubes except first video amplifier, high-voltage rectifier, and final amplifier are shown.

which are then rectified and filtered. This circuit provides approximately 1000 volts direct current for the iconoscope electron gun.

Single and double integration of the deflection voltages on the secondary of the output transformers results in parabolic and saw-tooth shading voltages at line and frame frequencies. These resulting voltages, which are capable of 180-degree phase variation, provide good shading-signal corrections under all operating conditions.

Since the number and size of the vacuum tubes used in the camera-transmitter unit (see Fig. 4) have been reduced drastically from those normally used, the power-supply dynamotor could be reduced to a very small value. The iconoscope heater power is supplied by a separate 6.3-volt section on the dynamotor. This section has been insulated for 1000 volts from ground, since the positive side of the iconoscope high-voltage system is at ground potential.

Simplifications which have been applied to the design of the camera-transmitter unit could not be applied, in general, to the receiver equipment, since the maximum possible sensitivity was needed in order to complement

the low radio-frequency transmitter power output. By judicious disposition of components it was possible to build a complete receiver, including the dynamotor power supply, into one case as illustrated in Figs. 5 and 6. The cathode-ray picture-tube type 7CP1 was chosen



Fig. 5—Receiving equipment SCR-550-T2. Top: receiver monitor; bottom row: monitor power supply, receiver-voltage-control box, receiver, and 100-megacycle "bazooka" just below.

in preference to the type 7AP4, because the green screen provided a picture of better contrast under high ambient light conditions. A green-light filter, placed in front of the screen, could be used to further attenuate the effects of the external stray light.

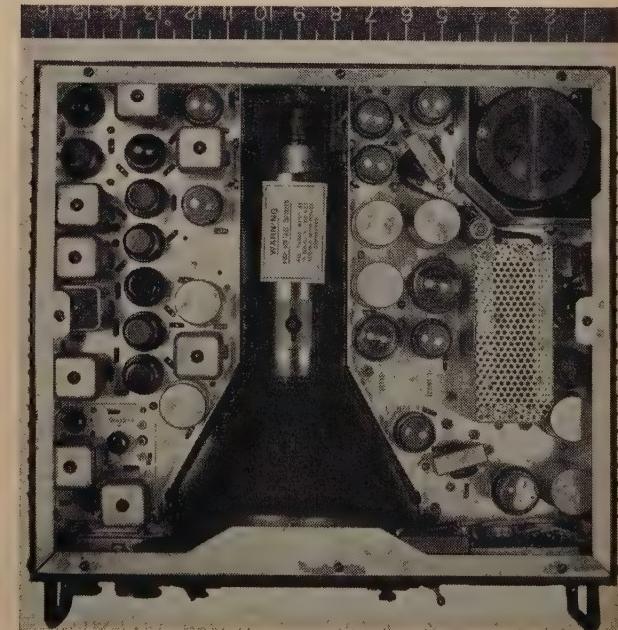


Fig. 6—Receiver of SCR-550-T2 showing radio-frequency, intermediate-frequency, and video amplifiers on the left side; deflection system, high-voltage power supply, and dynamotor on the right side.

For adjusting the performance of the camera-transmitter and for providing an additional picture at the receiving point, a monitor unit, as shown in Figs. 2 and 5, was designed.

Power is derived from the camera-transmitter when the monitor power plug is inserted into the rear of the

unit. This automatically transfers power from the transmitter to the monitor.

The transmitter monitor is somewhat different from the receiver monitor in that hold controls are incorporated. It was inconvenient to change the camera-transmitter units in order to use a directly driven monitor.

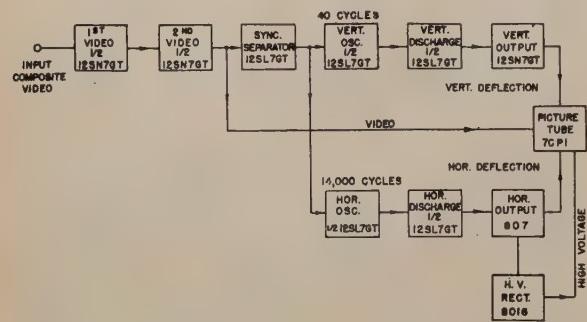


Fig. 7—Functional block diagram of monitor for 100-megacycle camera-transmitter.

Referring to the block diagram of the receiver, Fig. 8, it can be seen that the converter and intermediate-frequency portions of this receiver are in accordance with standard practice. The detector is coupled to the limiter

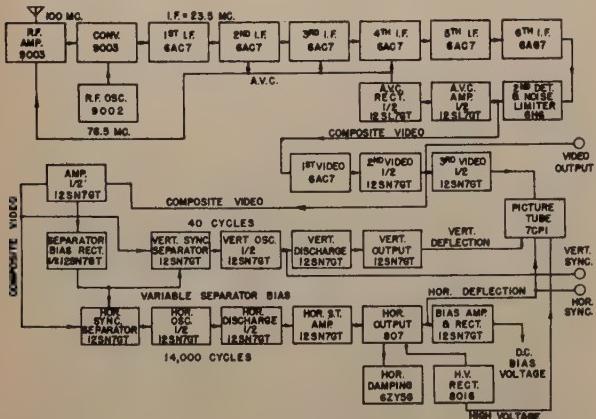


Fig. 8—Functional block diagram of 100-megacycle receiver.

through a video peaking circuit. The circuit of the limiter is arranged to clip noise pulses to a value slightly in excess of the synchronizing pulses. The limiter prevents the passage of noise-pulse amplitudes which would tend to override the synchronizing pulses.

The composite video signal from the limiter is then amplified and used to modulate the grid of the 7CP1 picture tube. It is unnecessary to eliminate the synchronizing pulses from the video and blanking signals, because these pulses drive the grid into the infrablack region of its grid characteristic and, thus, are not harmful to the picture.

Part of the composite video signal is amplified by an amplifier whose high-frequency response is just sufficient to pass the synchronizing signals. Three paths are provided for the output signal. One has a low-pass resistance-capacitance filter for passing only the vertical-synchronizing pulses. The second has a resist-

ance-capacitance filter for passing only the horizontal-synchronizing pulses. The third path provides a signal to a rectifier whose direct-current output is used to bias the separator tubes in proportion to the signal strength. By this means any vestige of the video component is removed and the synchronizing-signal amplitudes are held within reasonable limits. The synchronizing pulses are then used to "lockin" the blocking oscillators to achieve synchronization. The remainder of the synchronizing circuits are conventional with the exception of the high-voltage power supply for the 7CP1. Approximately 4200 volts is obtained from the rectified "kickback" pulse and to this is added the 300 volts from the dynamotor. Consequently, a total of 4500 volts is available for the picture tube. Filtering of the ripple voltage is rather simple because of the relatively high frequency of 14,000 cycles.

The automatic-volume-control system in the receiver is not in accordance with standard practice. In particu-

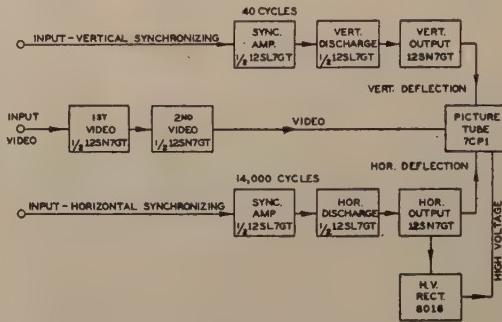


Fig. 9—Functional block diagram of monitor for 100-megacycle receiver.

lar, the automatic-volume-control rectifier and amplifier operate on the video voltage, rather than on the intermediate-frequency signal. Thus, compensation is made for the variation in light level and percentage modulation at the transmitter. Another feature of the automatic-volume-control system which deserves special mention is its low time constant. In airplane-to-airplane transmissions, rarely does the field strength at the receiver remain reasonably constant. On the contrary, it fluctuates widely from zero to maximum at a rather rapid and unpredictable rate. The automatic-volume-control system must be capable of following these variations. Actually, the time constant was so low that the shape of the vertical-synchronizing pulses was affected. Compensation for this effect was made in the vertical synchronizing separator.

The receiver monitor is in accordance with conventional design, as can be seen from Figs. 5 and 9. Horizontal- and vertical-synchronizing pulses are obtained from the receiver and are used to drive discharge tubes directly; therefore, the bothersome hold controls are eliminated. The remainder of the monitor circuit is similar to its counterpart in the receiver. Power for this monitor is obtained from a separate dynamotor power unit.

During the experimental testing of the T1 equipment,

it became apparent that an insufficient number of units was available to continue the test work efficiently. An additional quantity of 100-megacycle transmitters and receivers, designated SCR-549-T2 (see Fig. 10) and

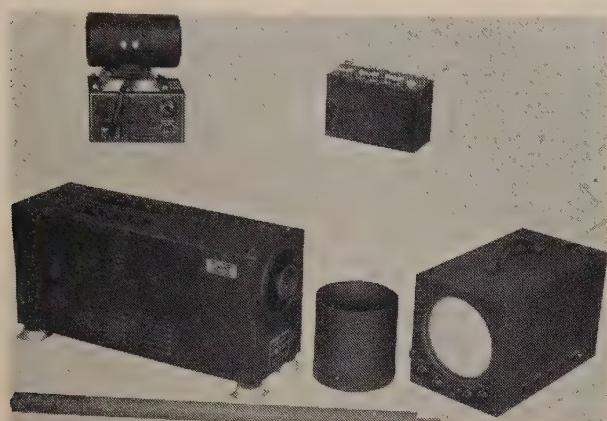


Fig. 10—Transmitting equipment SCR-549-T2. Left to right, upper row: dynamotor and junction box, 7-cell storage battery; lower row: camera-transmitter, transmitter monitor with light shield, and 100-megacycle "bazooka."

SCR-550-T2 (see Fig. 5), were procured. They differed very little from the T1 equipment as to external appearance; however, there were many detail changes that were made in order to expedite production and to simplify installation. Further exposition of the details of these units would not add any worth-while technical data to this paper.

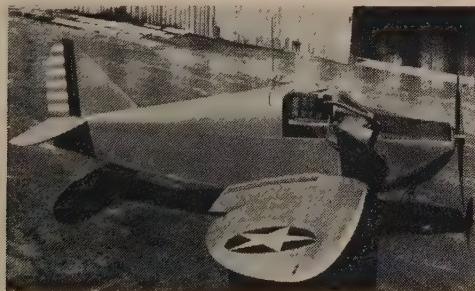


Fig. 11—PQ-8 target airplane with television camera-transmitter on right side in the cockpit.

Many minor circuit modifications were made at Wright Field in order to obtain satisfactory results under flight-test conditions. Several changes were necessary because of inexperience with the installation problems of television in small aircraft. Numerous others were due to unforeseen flight conditions on which there was no previous experience that could be called upon for guidance.

FIELD TESTS OF 100-MEGACYCLE EQUIPMENT

The T1 equipment was delivered early in 1942 and flight-test work began immediately at Wright Field. A B-23 airplane was equipped to carry either the transmitting or receiving equipment. A ground station in a half-ton truck was used for the other end of the television link and for maintaining radio communication with

the B-23 airplane. The first results did not appear encouraging and a considerable number of experimental changes were made, some being retained as worthwhile and necessary, while others were immediately discarded. When results began to improve, a set of transmitting equipment was installed in a small PQ-8 target



Fig. 12—Remote control pilot's installation in B-23 airplane.

airplane, shown in Fig. 11, while the receiving equipment was installed in a B-23 airplane (see Fig. 12). Tests at both Eglin Field, Florida, and Wright Field, Dayton, Ohio, demonstrated that airborne television was practical but emphasized the need for equipment design utilizing the best quality of components and workmanship.



Fig. 13—100-pound practice bomb being suspended under PQ-8 target airplane. This plane was flown "nullo" by radio control. The television camera-transmitter was located on the left side in the cockpit.

Upon close examination of Fig. 11, it will be apparent that the television camera must look through the propeller disk. The light-reducing effect comes in the form of pulses, one pulse per blade. For typical small engines, the frequency generated is approximately 80 pulses per second, or two bars per frame. The engine is not usually in synchronism with the vertical oscillator, so that, if the pulse generated by the propeller just precedes the vertical-synchronizing pulse, synchronization of the receiver will be seriously disturbed. Since there were no plans to use small, single-engined aircraft as missiles, little effort was concentrated on finding an exact solution for this problem. A fair solution was found by reducing the low-frequency response of the video amplifier.

This was done by reducing the coupling capacitor between the fourth and fifth video stages to a low value such that the attenuation of the low frequencies extended to about 8000 cycles per second. (Fig. 19 shows a typical television scene in which the low frequencies have been reduced in amplitude.)

During the latter part of 1942, a complete PQ-8 radio-controlled target plane, similar to that in Fig. 13, was flown at simulated targets by means of the television picture transmitted back to the control airplane. This was one of the first airplanes to be flown "nullo" (pilot-less airplanes flown from another airplane by means of radio remote control) with a television camera to aid in steering collision courses with fixed and moving targets. This airplane did not have adequate payload to be used as a missile.



Fig. 14—General Motors "Bug" showing 100-megacycle television antenna on top of fuselage and nacelle containing camera-transmitter underneath.

During the month of May, 1943, tests were made at Muroc Lake, California, using the General Motors Bug as a guided missile. SCR-549-T2 transmitting



Fig. 15—100-megacycle television camera-transmitter suspended under General Motors Bug.

equipment was installed in the Bug, while SCR-550-T2 receiving equipment was installed in a B-23 control airplane (see Fig. 12). In this particular installation, the television camera-transmitter unit was suspended beneath the fuselage of the Bug, housed in a streamlined nacelle, while the antenna was mounted on top of the

Bug (see Fig. 14). The radio-control and flight servo equipment were mounted on the inside of the fuselage.

The location of the camera was such that a large part of the viewed scene was intersected by the path of the propeller (see Fig. 15). Although in this case the problems were not as serious as with the PQ-8 type aircraft, where the entire scene was viewed through a rotating propeller, there was a definite effect from the propeller resulting in the generation of low-frequency transients. A similar modification as that made in the case of the PQ-8 was made here; that is, a reduction in the amplifier gain at low frequencies.



Fig. 16—General Motors Bug being taxied by radio control from B-23 airplane at Muroc Lake, California.

After all the necessary ground checks had been completed (see Fig. 16), the Bug was launched and a successful television picture was obtained during the whole flight. The Bug was finally dived into a target by radio control using television as a means of guidance.

An interesting feature which developed during the tests with the Bug was the determination of the angle between the line of flight of the missile and the line of



Fig. 17—YPQ-12A target airplane showing nacelle for camera-transmitter under right wing. In bomb position, a 500-pound bomb is placed in pilot's cockpit.

sight of the camera. It must be realized that the angle of attack of an airplane wing will change with airspeed. Thus, the angle between the line of sight of the television camera and the line of flight of the missile will change. Also, the navigation of a guided missile towards the target area requires a steeper angle than the diving angle of the missile when on the final run. A compromise solution was finally agreed upon and proved to be very successful.

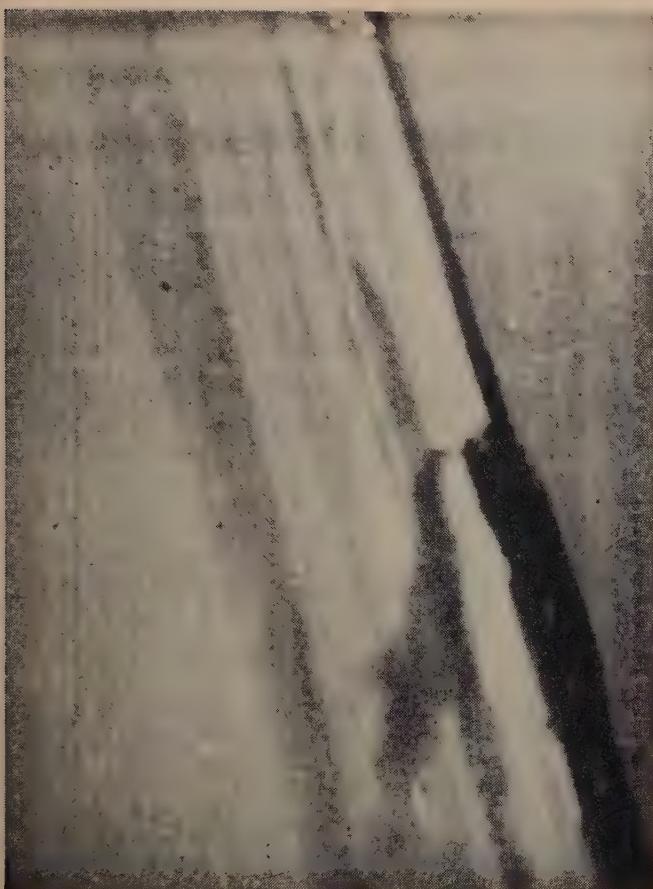


Fig. 18—Base area at Muroc Lake, California, showing fine streaking due to high-frequency microphonics and "highlighting" of mountain range in background due to loss of low frequencies. Photo taken from motion-picture sequence as recorded from 100-megacycle receiver.



Fig. 19—Moving train as seen on television screen at Muroc Lake, California. Camera was located in YPQ-12A airplane making simulated attack.

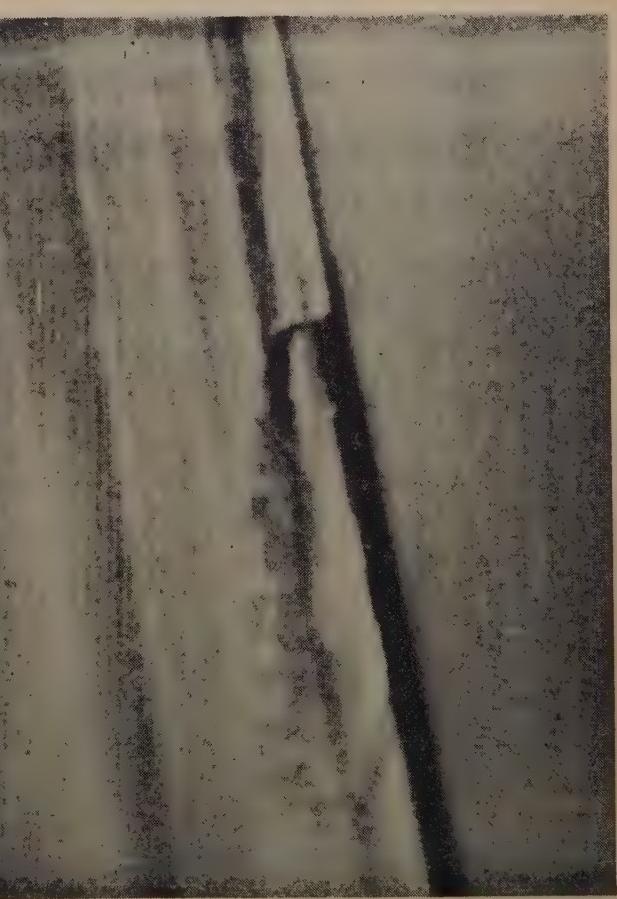


Fig. 20—Target of Fig. 19 a few moments later. Note the microphonics which reduce the resolution. White area in foreground is a dry lake bed, while the dark band in the background is an area of higher elevation.



Fig. 21—Dry-lake area at Muroc Lake, California, as seen by television camera in YPQ-12A. Monotony of landscape makes identification difficult.

The use of a television transmitter and a radio-control receiver operating in close proximity in the missile made special protection of the radio-control receiver imperative. Freedom from interference was obtained by the addition of a wave trap in the antenna circuit of the radio-control receiver. No interference was observed between the radio-control transmitter and the television receiver in the control airplane.

During August, 1943, it became apparent that all of the units of the power-driven bomb, that is, aircraft, power plant, flight servo, radio control, and television equipment, had been sufficiently developed to warrant a demonstration before interested military officials. Therefore, an expedition was dispatched to Muroc Lake, California, for the purpose of testing the military possibilities. In this case, SCR-549-T2 transmitting equipments were installed in YPQ-12A target airplanes to be used as power-driven bombs. The YPQ-12A airplane (see Fig. 17) was of the single-engine type, and therefore it was necessary to mount the television camera so that its line of vision would be outside the propeller arc. A nacelle for holding the camera-transmitter was mounted underneath the right wing of the airplane just outside the propeller disk. A lead weight was mounted on the left wing tip to counteract the unbalancing effect of the television camera on the right wing.

In spite of shock-mounting and acoustic treatment of the camera, the exhaust, propeller, and wind noises were so great (Fig. 23) that it was necessary to alter the low-frequency response such as to omit the fundamental frequencies of acoustic interference. The method used was the same as was previously outlined for use with the PQ-8 and the General Motors "Bug." Since it was not necessary to "look through" the propeller, the loss of low frequencies and the resultant increased phase shift were not as harmful to the final picture as might be supposed. In fact, from a military point of view the picture was improved, since the objects had a high light or contrasting border which aided in finding the target and in keeping the eyes fixed on it. See Figs. 18, 19, and 20.

During the preliminary tests, approximately 10 hours of flight were made in which a YPQ-12A was under direct radio remote control and during which the television picture was the sole source of information for the control pilot. The control airplanes were either an AT-7 or a B-23. Except for a vacuum-tube failure, the equipment gave no difficulty during the entire test program.

For the final or bomb run, a 500-pound bomb was placed in the safety pilot's cockpit and a hatch was used to cover the compartment. The television picture was adequate so that complete control over the missile could be maintained at all times. For its final run, the missile was controlled to a position directly behind a PQ-8 (Fig. 21) radio-controlled target and then exploded by means of the radio-control equipment. The television picture in the control plane was excellent, and it was possible to explode the bomb approximately 75 feet behind the target airplane. Later, on the same day, another YPQ-12A was flown into a ground target. Figs. 22

and 23 show the type of landscape at Muroc Lake, California. During this entire test program no new difficulties developed that had not already been discovered previously.

DEVELOPMENT OF 300-MEGACYCLE EQUIPMENT

As a result of the tests with the 100-megacycle equipment, it was demonstrated that light-weight television equipment was feasible for use in guided missiles. These sets, however, had a number of inherent limitations which made their use as military equipment undesirable. Therefore, it became necessary to formulate new specifications as to performance and operation.

The performance limitations which ruled out the further use of the 100-megacycle equipment in guided missiles can be summarized as follows:

1. The primary input voltage of the 100-megacycle equipment was 12.5 volts direct current. As this equipment was to be used in power-driven missiles having a 28-volt direct-current electrical system, it would be necessary to change the equipment for 28-volt operation.



Fig. 21—PQ-8 target airplane under radio control from L-5 airplane underneath. This was just prior to assault by YPQ-12A airplane as power-driven bomb.

2. There was only one radio-frequency channel available and this located in a region of considerable interference. Tactical considerations necessitated the availability of additional channels to permit the simultaneous operation of several missiles.

3. Some of the radio-frequency energy was coupled from the transmitter section into the camera section. This was a result of the combination of transmitter and camera section into one chassis.

4. Excessive antenna size, which prohibited the use of this equipment in small missiles.

5. Equipment would not operate at high altitudes or under extreme conditions of temperature and humidity to be expected in military operations.

While a few of the 100-megacycle equipments had been built as experimental models to explore the possibilities of television in guided missiles, it was realized that quantity procurement could be anticipated.

If success is to be achieved in the design of equipment for expendable missiles, the philosophy of low cost has

to be disregarded entirely. While missiles have no recoverable material, they must be extremely reliable. Since the cost of the television equipment (approximately 2000 dollars) represents only a small portion of the cost of the entire missile, especially in the case of the "war-weary" aircraft, savings are not justified if they result in unsuccessful missions. Therefore, it was emphasized that, although the equipment was expendable, design and production had to be according to standard Signal Corps requirements, which represented, closely, actual conditions that would be encountered in military use of

In addition, a number of improvements were incorporated which had been found to be of importance during field tests with the 100-megacycle equipment. For instance, it was discovered that if the equipment were left in an airplane overnight, and the airplane was parked in an East-West direction, the rising and/or setting sun would permanently injure the mosaic of the iconoscope. The result would be a heavy black streak in the picture where the mosaic had been "burned" by the sunlight. Thus, it became imperative to provide some kind of automatic-shutter mechanism (see Fig. 24) that would

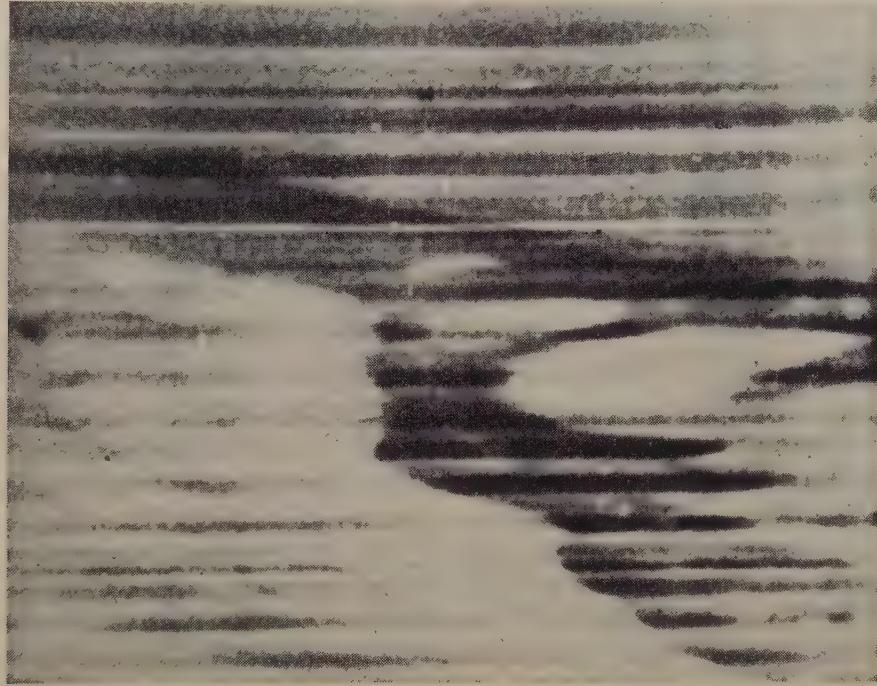


Fig. 23—The same general area as Fig. 22, showing effect of severe low-frequency microphonics (about 700 cycles per second).

airborne radio equipment. It was often necessary to make compromises in the interest of size and weight, in which cases deviations from the standard requirements were permitted. In making these deviations good judgment had to be applied, as the consequence of permitting the performance of an equipment to be limited by certain factors may be far reaching. For instance, in the beginning, when it was planned to fly guided missiles at high altitudes, the requirement for satisfactory operation at low air pressures and extremely low temperatures was formulated. When it was later found that it would be necessary to heat the interior compartments of the missiles because of the inability of the flight servo equipment to operate under extremely low temperature conditions, temperature requirements on the television-transmitting equipment could be somewhat relaxed. However, this was not the case with the receiving equipment which would have to operate in an unheated control plane.

The new 300-megacycle equipment, which was to incorporate all the aforementioned features and would avoid the limitations of the 100-megacycle equipment, became known as the SCR-549-T3 and the SCR-550-T3.

protect the iconoscope when the equipment was not in use.

Another matter that became important with the field use of this equipment was the problem of fogging of optical surfaces. In the projected use of guided missiles, in which the missile would be carried or flown at high altitudes and then dived into a ground target, the sudden change in temperature, air pressure, and humidity could produce conditions which would make lens fogging so complete that no picture information would reach the mosaic. An investigation showed that it would be necessary to heat the front window of the missile, the front of the television-camera lens, the lens barrel (to prevent the inside surfaces of the lens elements from fogging), the rear of the lens, and the front surface of the iconoscope.

During field tests, it was discovered that interference was caused by vibrations and noises set up in airplanes carrying the television equipment. This would manifest itself as horizontal black lines through the picture. The effect was caused by mechanical and/or acoustical coupling between the equipment and the airplane. These vibrations and noises were causing the elements of the video-amplifier tubes to vibrate with large amplitudes,

which, in turn, resulted in a change in transconductance and interelectrode capacitance. In the SCR-549-T1 and T2 equipments, the first stage of the video amplifier was separately shock-mounted, but field tests indicated that this was insufficient. During most of the tests, these microphonics became so bothersome that it was neces-

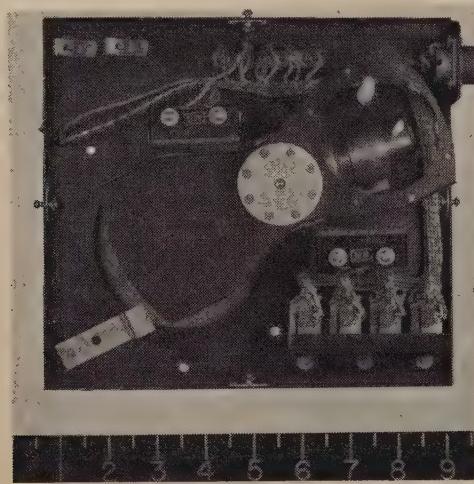


Fig. 24—Interior view of remote-controlled shutter for camera lens. The yellow filter is on the right-hand side in the vane. The driving motor can be seen through the yellow filter.

sary to reduce the low-frequency response of the amplifier, as has been previously described. In the case of the 300-megacycle equipment, an improvement was found by mounting the first three stages of the video amplifier on a separately shock-mounted chassis, as shown in Fig. 25.



Fig. 25—Top view of camera BC-1211-T3 showing 1846 iconoscope and shock-mounted video amplifier at top right.

During experimental flights with the 100-megacycle equipment at Muroc Lake, California, it was noted that the amplitude of the transmitted synchronizing signals, which were grid modulated, varied with the amount of contrast in the picture. This was a result of the fact that, in this system, no direct-current picture information was transmitted, as indicated before. As a consequence, the synchronizing signals were clipped under conditions of high contrast. Experiments were made with a unit in which the synchronizing signals were plate-modulated instead of grid-modulated. This made synchronization much more stable, and the results were so encouraging that it was decided to make this change permanent in all future equipments.

The operation of the 300-megacycle television set is

essentially similar to that of the 100-megacycle equipment, but differs as to details. In the case of the transmitting equipment, Figs. 25, 26, and 27 show that the camera-transmitter unit has been separated into two units. Video and synchronization have been separated and modulate the grid and plate, respectively, of the power amplifier. In the case of the camera (see Fig. 28), the function is the same as in the 100-megacycle equipment. A synchronizing amplifier and mixer have been

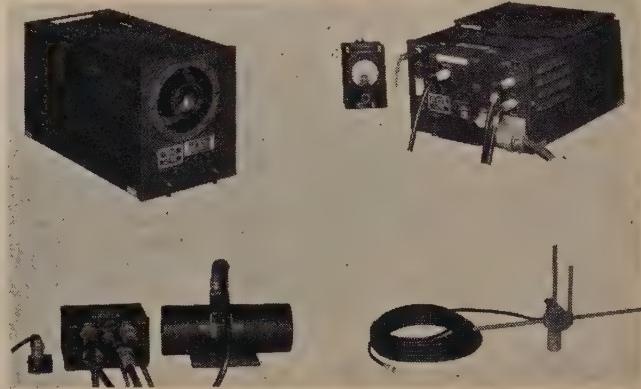


Fig. 26—Radio transmitting equipment SCR-549-T3.

added to standardize the output to the transmitter and monitor. A novel manner of heating the iconoscope filament eliminated much difficulty with commutator rip-

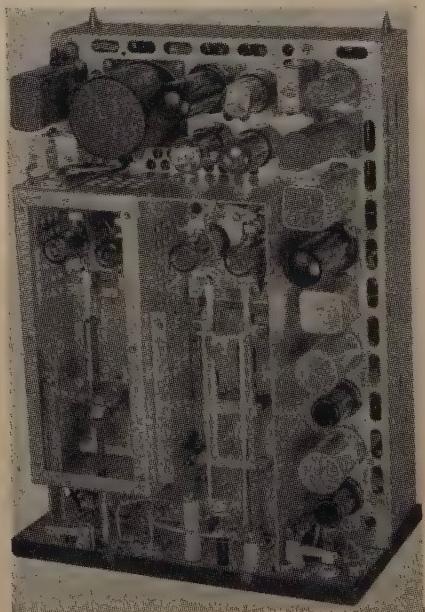


Fig. 27—Radio transmitter BC-1212-T3; master oscillator on left side, power amplifier in center, video amplifier and modulator at left side, and synchronizing amplifier and modulator at top.

ple. The filament voltage was derived from a separate 6L6 amplifier tube which was driven by the horizontal sawtooth voltage. As a result, any remaining ripple would be in synchronism with the deflection and would not form moving patterns.

Experience with the cameras of early units indicated that more care would be required in the design of the video amplifier with regards to low-frequency

microphonics. A leveler or "clamping" circuit was devised such that the low frequencies eliminated by the use of small coupling capacitors in the video amplifier are in effect reinserted by the fifth video stage. Since the amplitude of the leveler pulse from the horizontal output transformer was insufficient, it was fed into the first video amplifier and amplified by the remaining stages. The polarity of this pulse was such that it drew grid current in the fifth video stage.

In the camera section of the 100-megacycle transmitting equipment, a particularly troublesome effect was the formation of a horizontal bright bar across the top edge of the received picture. Because of its intensity, the receiver brightness control could not be advanced to the desired point without having the top edge of the picture "bloom." This bright band of light was very disturbing to the eye and contributed to the difficulty in locating or discerning objects on the screen. The cause was finally determined as an undesired pulse which was produced by the vertical blanking pulse in cutting off the iconoscope beam. This was corrected by introducing a vertical pulse of opposite polarity for the purpose

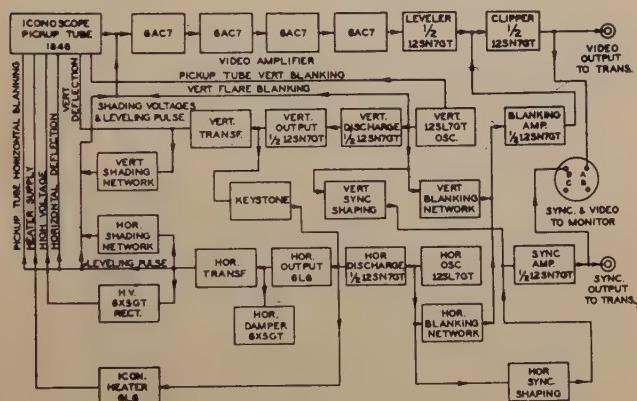


Fig. 28—Functional block diagram of camera for 300-megacycle equipment.

of neutralizing the unwanted effect. The undesired "flare" pulse generally occurred at a time such as to destroy the vertical blanking just prior to the start of the frame. The "flare" blanking pulse restored proper vertical blanking but produced a slightly wider interval than was desired.

In comparing the functional block diagrams, Figs. 3 and 28, it will be seen that the pickup tube in the T1 camera is a type 1848, whereas that in the T3 equipment is a type 1846. The difference between them, for all practical purposes, is minor; however, from a production standpoint the latter is easier to produce in quantity because of certain simplifications. The tubes can be interchanged in the camera units with only minor readjustments.

Iconoscope bias or back-lighting was incorporated in the T3 and A camera units because of the increase in contrast which resulted.¹² Sufficient light was provided

¹² Harley Iams, R. B. Janes, and W. H. Hickok, "The brightness of outdoor scenes and its relation to television transmission," PROC. I.R.E., vol. 25, pp. 1034-1047; August, 1937.

by a Mazda type 313 lamp rated at 28 volts and 0.170 ampere. Early tests did not show a need for bias lighting since they were made under high light conditions. Under these conditions some of the light passed by the lens was reflected, by various means, onto the rear portion of the iconoscope. By this means a form of bias lighting was achieved.

As in the 100-megacycle design, the cathode-follower clipper had a fixed value of grid bias so as to provide a fixed pedestal amplitude. Differing from the first design, the synchronizing signals were not mixed with the video and blanking signals.

From the camera, the video and synchronizing signals were sent to the transmitter over standard 50-ohm

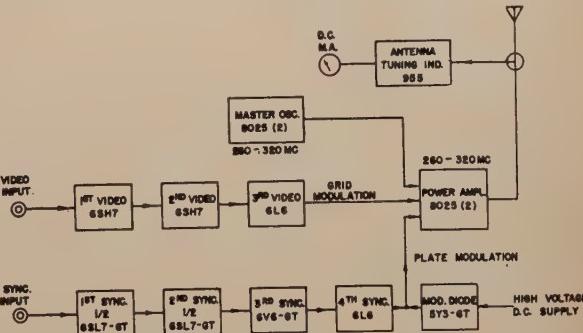


Fig. 29—Functional block diagram of transmitter for 300-megacycle equipment.

coaxial cable, RG-8/U. Their peak amplitudes were required to remain constant in order to prevent excessive variations in the percentage modulation. Video and synchronizing signals were available on another connector of the camera for the monitor unit.

The transmitter was designed to cover a range of from 260 to 320 megacycles. This wide frequency range with one set of tuning elements indicated that variable tuned lines would best serve the tuning requirements. The oscillator and amplifier plate lines may be seen in Fig. 27. The filament lines are under the chassis. The type 8025 tube was the only one available, at the time, which met all the requirements.

The video amplifier in the transmitter requires three stages because of gain and polarity considerations. Two high-gain stages would have been sufficient but would not result in the proper video-signal polarity. A modulation control was incorporated in this amplifier in order to compensate for changes in gain produced by vacuum-tube variations.

The synchronizing amplifier requires three stages for gain and polarity considerations, since the fourth stage is a cathode follower. The impedance of the power amplifier is quite low during the time in which the synchronizing signals are to be added to the blanking pedestal. The cathode follower, therefore, provides this impedance-matching function. The plate current for the power amplifier is supplied through the rectifier tube in order that an infinite back impedance be provided to the video coupling tube and power amplifier.

The transmitter was provided with a diode rectifier

which operated from the radio-frequency energy in the antenna circuit. Tuning of the transmitter was simplified by the use of this indicator. Plate- and grid-current jacks were also provided for ease in tuning of the radio-frequency lines.

The antenna, shown in Fig. 26, consists of a quarter-wave radiator with reflector. A matching stub forms the

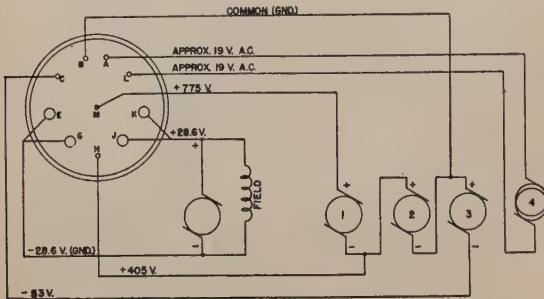


Fig. 30—Diagram of dynamotor showing four output sections on one shaft.

supporting base and is factory adjusted and fixed to match RG-8/U cable to the transmitter. The ground plane is simulated by a half-wave horizontal rod. Each radio-frequency channel was provided with an antenna designed for that particular frequency.

The conflicting power requirements of the camera and transmitter presented a serious problem in power-supply design because of size limitations. A solution was obtained in the dynamotor, as shown in Fig. 30. It will be noted that there are four output sections, two high-voltage, one bias-voltage, and one alternating voltage.

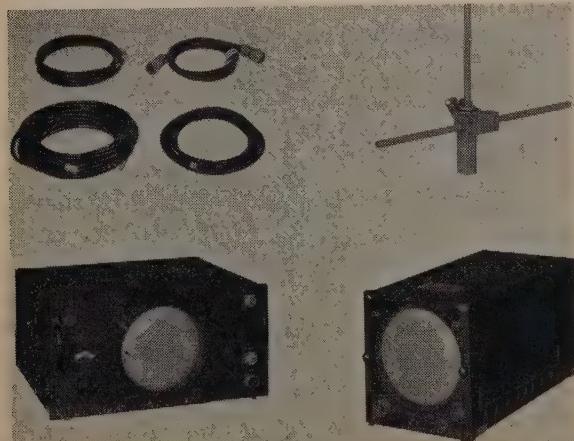


Fig. 31—Radio receiving equipment SCR-550-T3.

The two high-voltage sections are connected in series because of the difference in current requirements at the two voltages. The alternating-current output delivers 19 volts at 90 cycles per second, which is obtained by connecting slip rings to the motor armature coil.

The last versions of the 100-megacycle receivers operated so successfully that it was necessary to make but a few significant electrical changes in order to achieve the 300-megacycle design (see Figs. 31 and 32). The converter section, of course, was a completely new design. In the part of the frequency spectrum around 300 mega-

cycles it becomes necessary to utilize tuned lines as the tuning elements of the radio-frequency circuits. The high loss inherent in the coil and capacitor combinations rule out any thought of their use in receiver circuits, especially those which do not operate at fixed frequencies. This receiver employs two gang-tuned radio-frequency lines for converter and oscillator, respectively. By a suitable choice of gears it was possible to achieve good tracking of the oscillator and mixer lines.

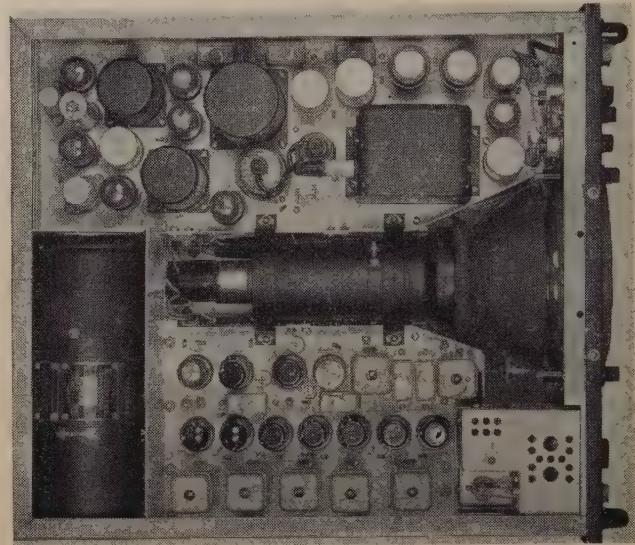


Fig. 32.—Radio receiver BC-1213-T3; top view showing converter, intermediate-frequency amplifier, and video amplifier at the bottom. Deflection and high-voltage circuits are at the top.

The 23.5-megacycle intermediate frequency resulting from heterodyne action is passed through six stages of amplification, and is then rectified to produce a video signal (see Fig. 33). The bandwidth of this amplifier is approximately 9 megacycles. A noise limiter has been

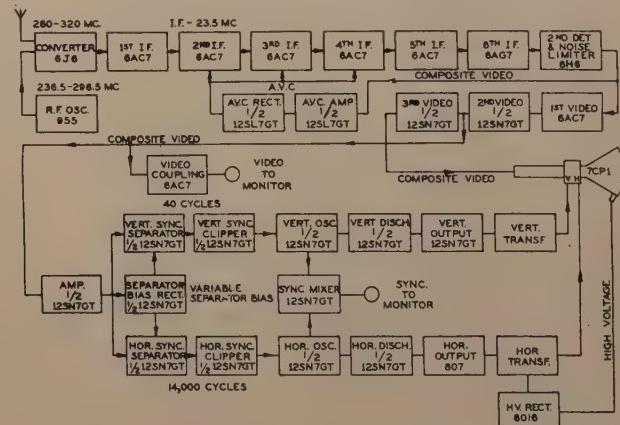


Fig. 33—Functional block diagram of 300-megacycle receiver.

incorporated, as in the 100-megacycle receiver. The detector output is amplified and rectified to provide automatic-volume-control voltage to the second, third, and fourth intermediate-frequency amplifiers. The detector is also followed by a three-stage video amplifier whose output voltage is applied to the 7CP1 picture tube.

The video signal from the second detector and noise

limiter is amplified by another tube and used to drive the synchronizing separators. Here, the video signal is "clipped" and the horizontal and vertical pulses are separated from each other in their particular separators. The clipping-bias voltage is provided to them from the variable clipper-bias rectifier. The resulting pulses, which then have the proper shape, are used to trigger the blocking oscillator and thus achieve synchronization. Each oscillator actuates a discharge tube to produce output voltages of saw-tooth wave form. The discharge-tube output voltages drive the output tubes, which in turn deliver saw-tooth current waves to the secondaries of the output transformer and deflection coils. High voltage for the operation of the picture tube is obtained from the horizontal output transformer and rectified by an 8016 tube.

The monitor unit, as shown in Fig. 34, is of the direct-driven (slave-sweep) type. It can be used either for observing the output of the camera or for providing an additional picture at the receiving location when it is driven from the output of the receiver.

Upon comparison of Fig. 35 with Fig. 33, it can be seen that the monitor duplicates video and synchronizing functions of the receiver. The one exception is that of the resistance-capacitance filter networks for sepa-

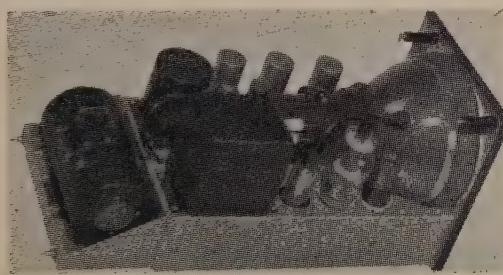


Fig. 34—Monitor unit BC-1214-T3.

rating the horizontal and vertical pulses. Separation provided here is sufficient to eliminate the need for blocking oscillators and, consequently, any adjustments when operating the monitor. The monitor can be separated from the receiver by any distance up to about 200 feet without loss of picture contrast. The contrast control at the receiver is so designed that it functions as master gain control; that is, a variation in its setting will produce a simultaneous variation in the video grid voltage applied to both the monitor picture tube and the receiver picture tube. This was done in order that the receiver and monitor pictures in a control airplane be identical under all operating conditions. The monitor is supplied with power from a self-contained dynamotor.

The SCR-549-A and SCR-550-A equipments need not be described since they are identical to the T3 equipment except for the quantities produced. A developmental model of the T3 equipment was submitted to the Aircraft Radio Laboratory for approval during December, 1942. Although preliminary inspection showed the equipment as being satisfactory, the first flight test gave an entirely opposite result; that is, the transmitted picture on the monitor was extremely good, but the re-

ceived picture in another airplane was hopeless. This reversal in the performance was quite a disappointment in view of the previous good performance of the 100-megacycle television equipment.

After a number of flight tests, it was observed that the interference appeared to consist of vertical black bars and dark spots covering the picture and disturbing synchronization. The fact that those phenomena only occurred in air-to-air transmission made it logical to assume that the interference was the result of reflections. After a number of flight tests had been performed it was found that the disturbance was caused by a combination of frequency modulation and multipath trans-

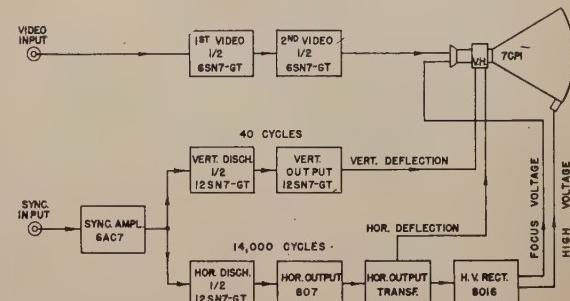


Fig. 35—Functional block diagram of monitor used with camera and receiver.

mission of the transmitted signal. It must be remembered that the particular transmitter employed utilized a power amplifier driven directly by a master oscillator, and, unlike the T1 equipment, no buffer stage was used. The master oscillator was tunable from 260 to 320 megacycles and was not crystal controlled. As a result of the modulation process, the power amplifier reacted on the oscillator, which caused a frequency deviation of as much as 200 kilocycles in early models.

The combination of multipath transmission and frequency modulation results in the simultaneous reception of two different frequencies in the receiver. This effect has been utilized to advantage in the frequency-modulation radio altimeter, but is undesired in the transmission of television pictures. The resulting beat note, due to the difference in the two frequencies, may be very low and, therefore, within the video band accepted by the receiver. Experiments were conducted to determine the maximum frequency deviation permissible which would not harm the picture. It was believed that any frequency deviation which was less than the picture line frequency, in this case 14 kilocycles, would have no harmful effects on the picture, and subsequent experiments proved this assumption to be correct. As a matter of fact, it was found that frequency deviations of a slightly larger magnitude could be tolerated; that is, up to approximately 20 kilocycles per second. A reduction in frequency modulation was found by changing the tuning procedure of the transmitter, and by reducing the load on the master oscillator. As a result the power output was somewhat reduced, but this did not materially affect the tactical use of the equipment.

Difficulties were also experienced, during early

experiments, with the electrical noise caused by the ignition system of the airplane engine. The receiver is very sensitive and ignition interference will manifest itself as small white dots in the picture, closely resembling a snowstorm. In addition, when the speed of the airplane engine is such that the electrical disturbances generated approach the synchronizing frequencies, synchronization is disturbed.

In this particular case, a thorough electrical "clean-up" of the engine ignition system reduced the noise to such a level that it did not affect synchronization. Although some video interference was still present, it was reduced to such a low level that it was not objectionable. Later, when this equipment was installed in tactical aircraft, particular pieces of equipment were often observed to interfere with the television receiver. These cases had to be solved individually, either by the installation of wave traps or by improved shielding.

In general, there are two classes of disturbances that can affect the picture. One class affects synchronization, while the other affects the video information. While any interference that affects the video information may be bothersome, it is not always too serious from a military point of view, as it is often possible to "see through" the disturbances and at least have a picture that is still partly usable. However, if the synchronization is disturbed, there is absolutely no information left and the picture is useless.

It might be observed that all through this paper various kinds of disturbances are mentioned which are of varying degrees of importance, according to their effect on the picture. Often one disturbance will affect both the synchronization and the video information, but in general, efforts were always made to eliminate the particular disturbance that affected the synchronization first. In case it would affect both synchronization and video, efforts were made to reduce it to such a point that it would not affect the synchronization, while further improvements to eliminate the video interference could be made later.

DEVELOPMENT OF SPECIAL TEST EQUIPMENT

After the camera-transmitter of the SCR-549-T1 had been in use for a short period of time, the inadequacies of the ordinary laboratory test equipment, especially the 35-millimeter slide projector, for adjustment of the camera-transmitter became apparent. A light projector and test bench, as shown in Fig. 36, were designed at Wright Field to assist in expediting flight tests.

The test bench consisted of an incandescent light source, test slides, projector lens, camera support, dummy antenna, power supply, and controls. By means of this laboratory-designed set, a camera-transmitter could be adjusted for its required final operating performance. Later, a fluorescent-light projector was used as the light source. Transparent slides were used in place of the reflecting test patterns because of the higher light efficiency. As the 300-megacycle equipment took tangible form, operating test equipment became an ab-

solute necessity. The test bench ultimately resolved itself into two units, namely, the I-231 and the I-232 (see Figs. 37 and 38).

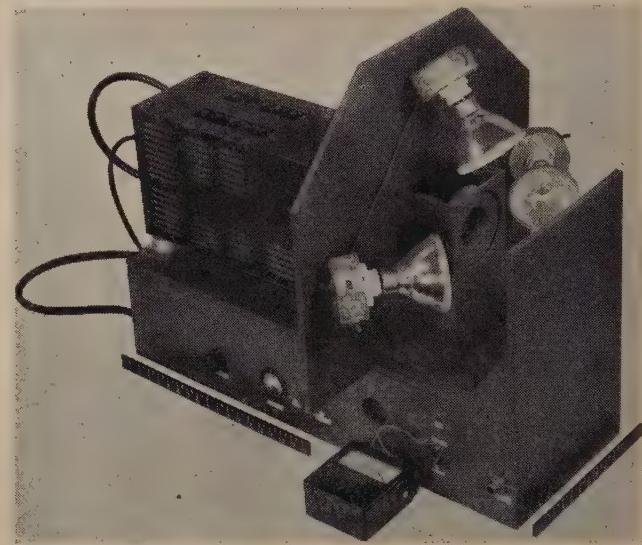


Fig. 36—Experimental test bench with 100-megacycle camera-transmitter in place. The test pattern was placed on the vertical support facing the projector lamps.

The I-231 served several functions, as follows:

- (1) A mounting base to align the television camera with the fluorescent projector.
- (2) A source of adjustable 28-volt direct-current power having several outlets and a circuit breaker.
- (3) 110-volt, 60-cycle outlets for other test equipment.



Fig. 37—Test set I-231.

- (4) Two ranges of low-voltage, 60-cycle alternating current, for oscilloscope calibration.
- (5) Relative-power-output meter.
- (6) Percentage-modulation meter.

By means of two cables, one to a source of 28-volt direct current and another to a source of 110 volts, 60 cycles, a complete test setup could be made available on short notice.

The fluorescent projector I-232 had as its light source a 6-watt daylight lamp which matched the spectral characteristics of the iconoscope. There were test slides for contrast, linearity, resolution, and over-all picture

quality. A large condensing lens and a cylindrical mirror were used to conserve the light energy, as in Fig. 39. A very convenient feature of this projector was the $8\frac{1}{4}$ -inch E.F. lens which projected parallel rays of light onto the television-camera lens. Under this condition, it was possible to adjust the focus of the camera lens to infinity and lock it into position. Thus, it was unnecessary to be concerned about the focus of the camera lens upon the installation of a camera in a missile.

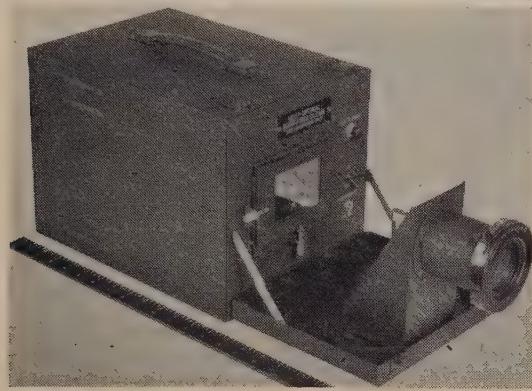


Fig. 38—Fluorescent projector I-232 ready for use.

The fluorescent projector calibration took into account the light loss in the camera lens directly in foot-candles equivalent mosaic illumination. An iris was designed for the front of the projection lens such that it was possible to provide known amounts of light of from one-half to twenty foot-candles on the mosaic. The fluorescent lamp was operated on direct current by means of the self-contained power supply. A current

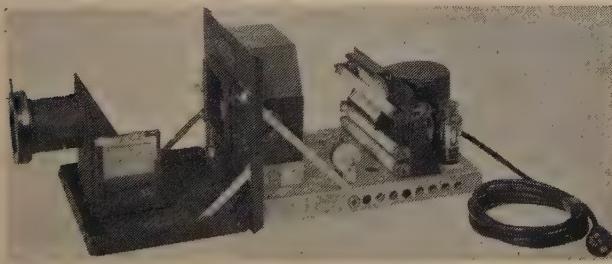


Fig. 39—Fluorescent projector I-232, showing, from right to left, power supply, 6-watt lamp with cylindrical reflector (spare lamps on the bottom), condenser lens with aperture for test slides, and projection lens with iris.

jack was provided so that the lamp current could be adjusted to a fixed and known value. Aging of the lamps within reasonable limits did not produce an appreciable difference in light output, as far as adjustment of a television camera was concerned.

With the advent of tests of the television equipment in aircraft, and particularly in missiles, the need for permanent records of the results became apparent. Missile flights are very short in some cases, and for that reason it is even more important that adequate information be available for critical examination. Engineers differ quite often as to the description of the picture faults, especially if some time has elapsed between the

tests and the time of discussion. To circumvent this condition, a motion-picture-camera recorder, shown in Fig. 40, was developed.

The television pictures in this paper were taken by the photorecorder as described above. In the construction of this device it was necessary to mount the television receiver and the motion-picture camera on a common base plate, in order to minimize the effect of differences in the vibration periods of the two units. A driving-motor speed control was used to adjust the

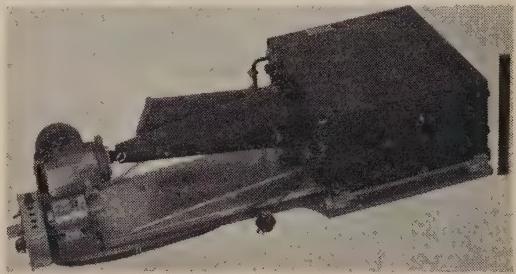


Fig. 40—Motion-picture camera for recording of pictures from the receiver screen. Note the observer's viewing position on left side of light shield.

speed of the camera shutter to about eight frames per second. Speeds as low as four frames per second were available, if required.

In viewing the television-screen pictures in this paper, account should be taken of the fact that the picture quality is somewhat inferior to that actually observed on the screen of the cathode-ray tube. There are many reasons for this deterioration, a few of which are listed below:

(1) In spite of the precautions observed in the con-

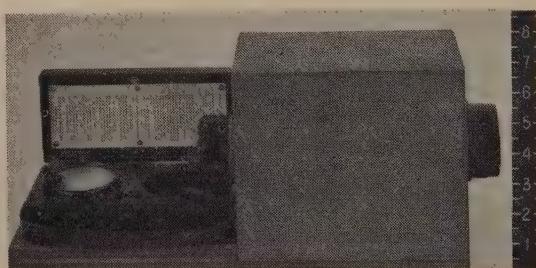


Fig. 41—Weston foot-candle meter mounted in device for obtaining comparative data as to equivalent mosaic illumination obtained at different test locations.

struction of a photorecorder, certain flight conditions in an airplane will cause the motion-picture camera to vibrate at a different period than the receiver, and a blurred picture will result.

(2) There are many photographic processes between the latent image on the film and the reproduced picture in this paper. Each one contributes very little distortion but the summation of all of them is quite noticeable. There is little that can be done except to use considerable care in all dark-room work.

(3) The picture reproduced on the television-receiver screen is never absolutely steady but has various instabilities that can be attributed to many causes. The

eye will often overlook or correct many of them. At slow shutter speeds of the motion-picture camera, these motions cause noticeable blurring of the picture.

(4) One other factor which reduces the information to be gained from pictures of a television screen is the lack of continuity of action in the still pictures as displayed in this paper. Some of them appear quite meaningless until they are studied for some period of time or an additional description is supplied. In general, if the scene could be interpreted by the naked eye, then a good television picture would reveal almost the same information. This assumes that none of the aforementioned defects are present in the picture; that is, the system is providing its best possible picture.

Illustrated in Fig. 41 is a light-measuring device for determining the equivalent mosaic illumination on the iconoscope. A standard Weston foot-candle meter is used as the indicator. Since the spectral characteristics of the iconoscope and foot-candle meter are dissimilar, a correcting light filter was placed in front of its photocell. A lens similar to that used in the television camera was placed in front of the photosensitive surface. This light meter was used only occasionally, but was quite useful when a new test location was surveyed. Its use was limited to experimental operations.¹³

FIELD TESTS OF 300-MEGACYCLE EQUIPMENT

After the frequency-modulation and ignition-interference problems had been solved, production of the SCR-549-A and SCR-550-A equipments was started and the first models of these equipments were accepted during the month of June, 1943. Preliminary laboratory and flight tests indicated that adequate performance could be expected. At the same time, a small number of GB-4 glide bombs became available, and the first installation

¹³ R. B. Janes and W. H. Hickok, "Recent improvements in the design and characteristics of the iconoscope," Proc. I.R.E., vol 27, pp. 535-540; April, 1939.

of SCR-549-A equipments in GB-4 glide bombs was completed during July, 1943.

The GB-4 glide bomb, shown in Figs. 42, 43, 44, and 45, consists of a standard 2000-pound bomb to which an

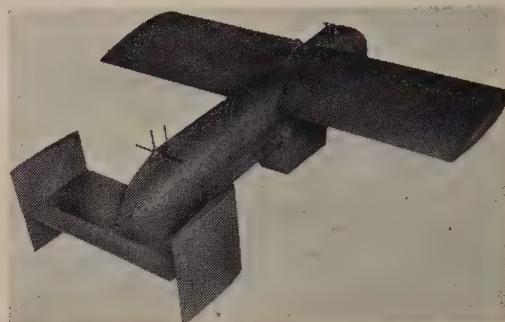


Fig. 43—Top view of GB-4 glide bomb. Television antenna is just ahead of horizontal stabilizer.

air frame has been fitted. The flight-servo equipment, radio-control equipment, and television-transmitting equipment are housed in the body of the air frame, while the camera is mounted inside a streamlined nacelle underneath the bomb. Two seven-cell storage batteries connected in series provide the necessary power for the

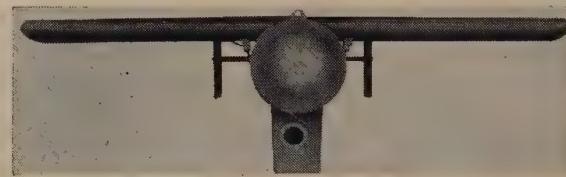


Fig. 44—Front view of GB-4. Note the large frontal area of nacelle due to use of acoustic case around the camera.

SCR-549-A equipment. The television transmitting antenna is mounted on top of the bomb towards the rear, with the reflector in the forward position.

After the installation had been completed and all equipment thoroughly checked, flight tests were made with the GB-4 hung under the control plane. A number



Fig. 42—Glide bomb GB-4 showing transmitter, storage batteries, junction box, and dynamotor in forward section, and radio-control and flight-servo equipment in the rear. Note felt hair on the inside of the air-frame cover.



Fig. 46—Television picture received from GB-4 glide bomb turning into pyramidal target at Eglin Field, Florida.

of dives were made at the target, consisting of a pyramid (see Fig. 46) to familiarize the control pilot with the television picture. An Air Corps trailer with two dark rooms and completely equipped for field tests served as an auxiliary receiving station during these flights. In addition to having complete test equipment for field alignment and repair of television equipment, the trailer had provision for motion-picture recordings of the television-receiver screen, as described previously.

After the first flight tests indicated that the installation and operation of the equipment was satisfactory, it was decided to drop a number of GB-4 glide bombs to determine the practicability of hitting a small target with this missile. Television equipment was installed in

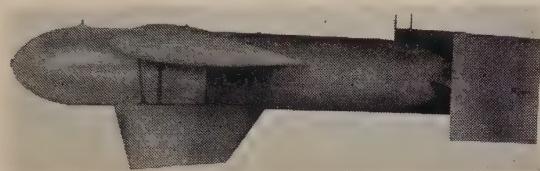


Fig. 45—Side view of GB-4. Slant of bottom of nacelle is due to downward tilt of the camera caused by the flight attitude of the glide bomb.

five GB-4 glide bombs which were dropped during August, 1943, at Eglin Field, Florida. Very bad television pictures were received in the control airplane, and in the beginning it appeared as though television in guided missiles could not be successfully realized. The picture was extraordinarily poor, having both horizontal- and vertical-synchronization instabilities, while most of the picture information was obscured by dark lines. In addition, the shading of the camera was generally unsatisfactory. The power output of the transmitter suddenly decreased to zero in one of the bombs after it had been released from the control plane, while on other bombs numerous disturbances would appear during flight. Some of these disturbances, such as the heavy streaking that occasionally would obscure the picture information, were also seen at the ground station. Other disturbances, such as the vertical black bars and those causing loss of synchronization, were observed most frequently in the receiving airplane.

It was fortunate, however, that motion-picture cameras had been set up to take pictures of the television screen both in the air and on the ground, and thereby a thorough analysis of the disturbances was possible. It was found that most of the disturbances were intermittent and varying in amplitude, enabling an individual analysis from successive frames of the motion-picture film. This investigation showed that the following interference effects were present:

(1) Fine horizontal lines in the picture, as in Fig. 47. These lines were produced by acoustic pickup in the camera, and their frequency was approximately 3000 to 4000 cycles per second. This high-pitched noise was apparently generated by the wind rushing past the GB-4 glide bomb, and a solution was found by placing the camera in a soundproof box.

(2) Heavy horizontal lines in the picture, as in Fig. 48. These lines were produced by acoustic pickup in the transmitter, and their frequency was approximately 120 to 200 cycles per second. This low-frequency noise was apparently generated by the plywood body of the air frame, which acted as an effective sound chamber or resonator. A solution was found by coating the inside of the airframe with automobile-body silencing compound and a thick layer of hair felt (see Fig. 42).

(3) Heavy streaking through the picture, as in Figs. 49, 50, and 51. This trouble was of an intermittent nature, and an investigation showed that the disturbance was caused by loose bonding. For example, one of the metal control rods was approximately one-half wave long with a hinge in the middle. Loose bonding in the hinge was apparently causing these streaks, and after all metal parts had been bonded no further trouble was experienced.

(4) Change in picture shading (see Fig. 52). This change was caused by the influence of the earth's magnetic field on the iconoscope, especially when the video gain control was turned up to a high level. The difficulty was overcome by an improved alignment procedure and installation of a magnetic shield around the entire iconoscope in addition to the shield around the electron gun.

(5) Change in power output of the transmitter. Examination of parts of the television equipment after the crash of several bombs revealed that the antenna tuning capacitor was often completely detuned. Vibrations in the bomb caused the capacitor to change its proper setting and was corrected by installing a clamping spring on the capacitor adjustment screw.

(6) Blooming of the top half of the picture and loss of video information (see Fig. 53). This trouble was caused by iconoscope saturation. Various experiments were conducted with combinations of lens stops and light filters, and it was found that a yellow filter was the most effective solution, especially under conditions of high light levels and low contrast caused by haze.

(7) Loss of synchronization and streaking. This was caused by radio-frequency feedback in the cables going from the camera to the transmitter. Installation of a few by-pass capacitors solved the trouble.

(8) Interference from the radio-control system. The radio-control system then in use utilized five channels between 80 and 90 megacycles. It was found that channel number 5 (88 megacycles) would seriously interfere with channel number 1 on the television band (264 megacycles), this being the third harmonic. The difficulty was overcome by proper selection of radio-frequency channels.

(9) Continuous-wave interference. This would manifest itself in a fine herringbone pattern obscuring the picture in a manner similar to interference produced by diathermy machines. This disturbance was caused by other transmitting equipment in the control airplane. A solution was found by improved bonding of the receiver antenna cable.

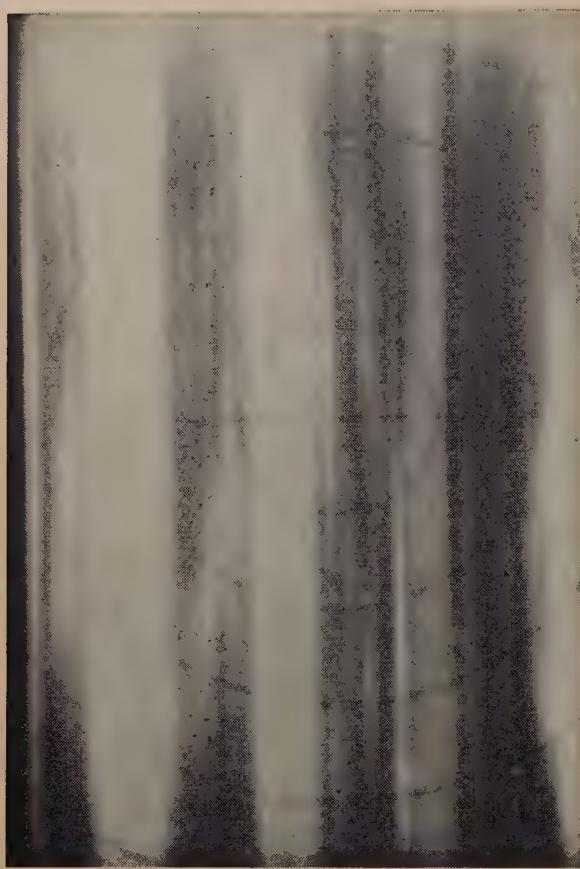


Fig. 47—Television picture received from GB-4 glide bomb. Pyramidal target with smoke haze can be seen in background; target information is obscured by heavy microphonics, frequency approximately 3000 cycles per second.

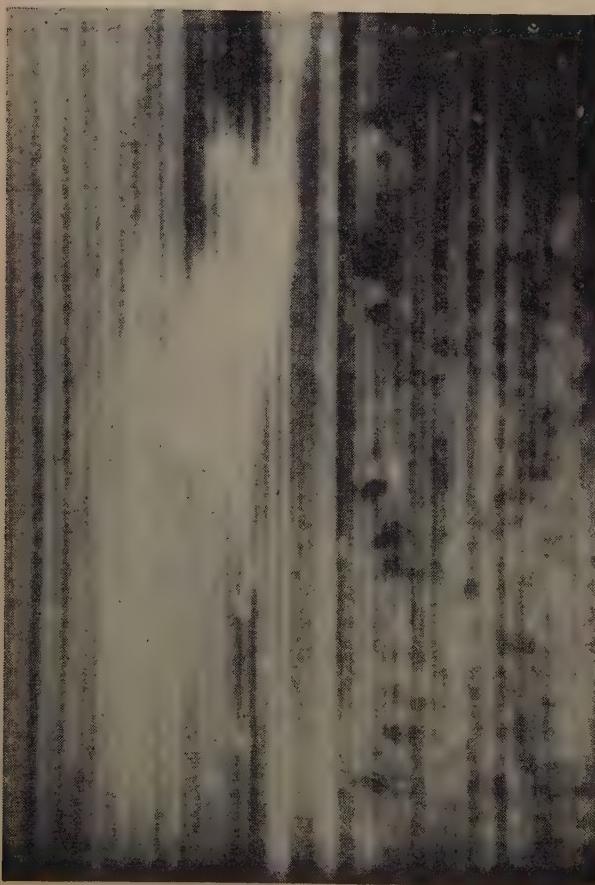


Fig. 48—Television picture from glide bomb shows wide bars due to microphonics of about 200 cycles per second. Target information is completely obscured.

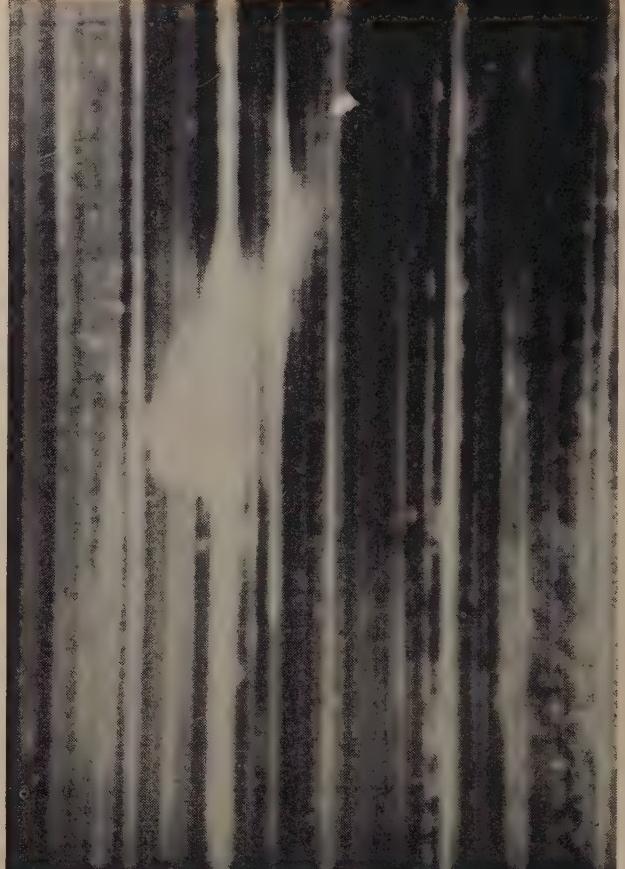


Fig. 48—Television picture from glide bomb shows wide bars due to microphonics of about 200 cycles per second. Target information is completely obscured.



Fig. 49—One of the first television pictures obtained from a glide bomb. White patch in the picture is the target area. White streaks are due to poor electrical bonding. This picture was taken just after the GB-4 was released from B-17 airplane.

Fig. 50—Pyramidal target practically obscured by white bars due to poor electrical bonding in GB-4 and smaller bars due to microphonics of approximately 3000 cycles per second in camera.



Fig. 52—Mountain range as seen via television from glide bomb. This picture is an enlargement of one frame of a 16-millimeter film. Observe the change in horizontal shading due to the influence of the earth's magnetic field.

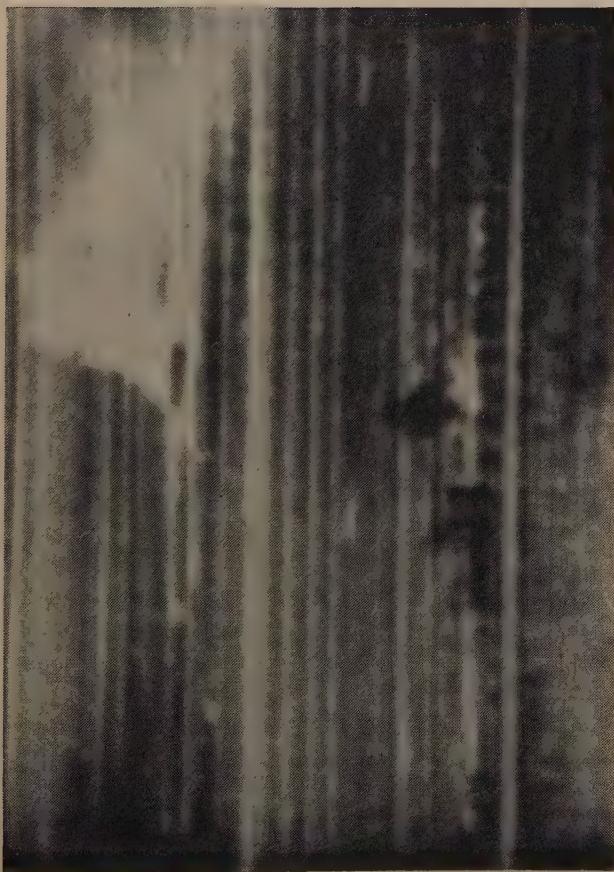


Fig. 51—Pyramidal target with streak due to poor electrical bonding just below it. Because microphonics are less severe, road and trees can be seen in the foreground.



Fig. 55—Target area at Eglin Field, Florida, as seen on the television receiver screen. Pyramidal target is in the center of the circular area.



Fig. 54—Target area at Eglin Field, Florida. The dark, wavy lines are trees along drainage ditches. The large triangle is approximately 1800 feet on the side.

Numerous other minor difficulties were encountered which occur normally in the testing of a new equipment. These difficulties were solved, however, and by November, 1943, a glide bomb was dropped at Eglin Field in which all these and other improvements had been incorporated. As a result, a flawless television picture was received in the control airplane during the whole flight (see Figs. 46, 54, 55, and 56).

By this time, the tactics of the use of guided missiles became more and more important, and it was realized that in order to make full use of this equipment—the

stabilized antenna mount (see Fig. 57) consisted of an upper part which would rotate, and a lower part which was fixed to the airplane. The upper part contained the gyro mechanism with the pick-offs which controlled the servo motor. The lower part contained the servo motor which would rotate the antenna and upper part. A slip ring on the top of the antenna mount permitted the feed-through of the coaxial antenna cable.

The mount was so constructed that the antenna would be directed forward in its normal position before release of the bomb. After release, the gyro mechanism



Fig. 53—Television picture from glide bomb, very close to target, Tonopah, Nevada. Parts of the target have been removed. Observe the "blooming" of the top half of the picture due to iconoscope mosaic saturation because of excessive light.

range, which was 12 to 20 miles at that time, would have to be increased. Experiments were, therefore, carried out in which a directional, narrow-band receiving antenna was used in the control airplane, instead of the conventional omni-directional wide-band antenna. It was realized that this would necessitate changing antennas on the airplane each time a different television channel was used. However, the increase in range obtained by this procedure (50 to 80 miles) justified the use of this antenna.

In order to permit the control airplane to maneuver freely and still make full use of the directional antenna, a gyro-stabilized antenna mount was designed to keep the directional antenna parallel to the course on which the GB-4 glide bomb had been dropped. This gyro-

would become uncaged, keeping the antenna stabilized from then on and still allowing the control airplane to take evasive action.

One of the greatest difficulties experienced with the use of antennas in conjunction with this television equipment was the fact that the antenna pattern, obtained by assuming the antenna to be located in free space, is of very little value. The fact that the antenna is mounted on a large metal airplane changes the pattern so completely that predictions are difficult to make. Some work was done by mounting antennas on airplanes in various places that were structurally accessible and that appeared to be likely locations for the antennas. Much was left to guess work and, consequently, many mistrials were made before the final solution was

found. At first, it was thought that the camera hatch in a B-17 airplane would be an ideal place to mount the antenna, as the gyro-stabilized mount fitted well in that location. Early experiments proved this assumption to be correct and good pictures were received until an installation was made in a tactical aircraft. The difference was that the tactical airplane had a ball turret (see Fig. 58), while the experimental airplane did not have one.



Fig. 56—Pyramid target at Eglin Field, Florida, as seen by television camera an instant before striking it.

The result was that serious reflections from the propellers and ball turret were encountered in this new airplane. Propeller modulation had not been bothersome before. The antenna was then moved toward the tail, but difficulties were encountered in mounting it in that position because of lack of ground clearance. Empirical data indicated that best results for a B-17 airplane could be obtained with the antenna as far back as possible and at least one-fourth wave below the skin of the ship. A compromise was finally found by mounting the antenna in front of the tail wheel. The installation operated satisfactorily until other considerations made it necessary to change the location again.

After the first television glide bombs had been dropped at Eglin Field and it became apparent that good television pictures could be obtained with this equipment, further experiments were carried out at Tonopah, Nevada (see Figs. 52, 53, 59, and 60). Approximately fifty glide bombs with television equipments were expended at Tonopah and much useful information was gained by these experiments. Specific weaknesses in the equipment were discovered and Army personnel was trained in the alignment and installation of the television equipment.

It was found, for instance, that certain iconoscopes had stronger microphonic tendencies than others, and therefore standards were set up with the aid of an acoustic noise box in which cameras were subjected to certain noise levels, similar to those encountered in ac-

tual practice. Iconoscopes could then be used if they passed this noise test.

Troubles were also experienced for the first time with lens fogging, and consequently, optical heating was installed in all sets.

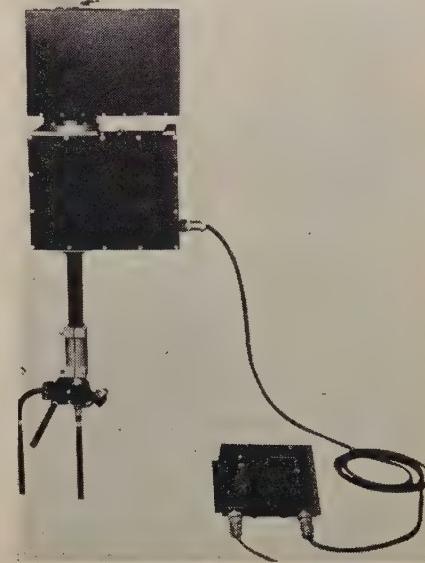


Fig. 57—Gyro-stabilized antenna mount for television receiving antenna on control airplane.

At that time, the first models of the lens shutters were also tested. This shutter (see Fig. 24) consisted of a rotating vane which had a normal opening and a yellow filter. The television operator could select either the full opening or the yellow filter by radio control, according to the light conditions prevailing at the camera.

The problem of reflections showed up when drops were made from altitudes greater than 6000 feet, but they were never too serious and usually disappeared



Fig. 58—B-17 airplane with one GB-4 glide bomb suspended on an external bomb rack.

when the bomb reached lower altitudes. A solution was found in changing the flying procedure of the airplane, after the bomb had been released. Although this flying procedure was obtained by sheer luck, it proved to be in accordance with data obtained later, when flights over water showed the reflection problem to be of paramount importance.

One of the greatest problems in guiding missiles with

the aid of television was target identification. In general, targets would be hit, or near misses scored, if the target could be identified, but often the operator, although thoroughly familiar with the terrain, would get "lost." One of the disadvantages of the television set, against a human pilot, is that the television set cannot "look around" in a manner similar to a pilot. Consequently, if for some reason the target is obscured or just outside the picture, it is very difficult to locate. Also, the minimum size of the target which can still be seen is, of

A glide-bomb operating group was ordered to England during June, 1944. Shortly afterwards, a "castor" group was sent to the same location.

"Castor" was the code word for the use of "war-weary" heavy bombers as guided missiles. The aircraft were to be loaded with explosives and guided into targets by means of television and radio-control equipment. The television camera was mounted in the nose of the aircraft, while the transmitter, power supply, and antenna were located in the tail. The equipment used was identi-



Fig. 59—Target area, Tonopah, Nevada, on television-receiver screen.

course, a function of the viewing angle of the lens in addition to the number of lines used in the picture. The ideal solution would have been to have a lens in which the viewing angle could be changed by remote control, so that if the control pilot got "lost" he could enlarge the viewing angle, which would be equivalent to the "looking around" of a human pilot. The equipment necessary to accomplish this process was found to be too complicated, and more emphasis was put on dropping the bomb accurately with a bomb sight and only using the television set for small corrections in the course. It was then assumed that if no radio control was applied to the bomb it would hit close to the target, but radio control and television were meant to make a direct hit out of what would otherwise be a near miss. Therefore, the viewing angle of the lens was left unchanged, as it was thought to be the best compromise between the size of the area viewed and the ability to distinguish objects.

cal to that used in the glide bombs, except that power was derived from the airplane's electrical system and a selsyn compass indicator was added to the camera. This compass projected a course reading directly on a small part of the iconoscope mosaic in the upper right-hand corner. This resulted in the indication appearing in the lower left-hand corner of the received picture. Its image was superimposed on the picture information projected directly from the outside by the lens. An example of such a compass-course projection shows the indicator graduations in the upper left-hand corner of each photograph in Fig. 70.

The receiver installation in the control airplane (see Figs. 61 and 62) was very similar to that of the glide-bomb control airplane. The gyro-stabilized antenna mount, however, had to be operated by manual control instead of by full automatic control.

The first two raids employing GB-4 glide bombs (see

Figs. 63, 64, and 65) were made against the submarine pens at Le Havre and La Pallice, France. These pens were located in such a manner that it was necessary to approach from over water. For tactical reasons it was decided to drop the bombs from 20,000 feet, and a modified flying procedure had to be established to prevent the control plane from getting out of range of the bomb. The new procedure allowed the control plane to fly in the same direction as the bomb for two minutes after release, then turn 180 degrees and head for home. Total flying time of the bomb was about six minutes.

During these first two raids such heavy interference

(2) After approximately one minute, the bar would have reached the left-hand edge of the picture, and synchronization became so unstable now that a regular television picture could not be maintained.

(3) After two minutes, the vertical synchronization would at least become stable, while the horizontal still remained unstable.

(4) After three minutes, a violent "flashing" effect was observed in which it appeared as if variations in outside illumination of the scene took place at a rate of about 2 cycles per second. Horizontal synchronization became more stable.



Fig. 60—Television picture from glide bomb close to target at Tonopah, Nevada. Although the contrast is good in this scene, identification of the target is difficult.

was encountered in the control airplane that the picture was useless for all practical purposes, although occasional glimpses of the target could be seen. An observation airplane, however, which stayed approximately 50 miles behind, had an excellent picture during the whole flight. This ruled out the possibilities of countermeasures and suggested reflections. The particular phenomena that were observed presented themselves in the following forms during one flight of a glide bomb:

(1) During the first minute, a vertical black bar would appear in the picture, approximately one-third picture width from the left side, and approximately one-quarter picture width wide. This black bar would obscure all video information completely and would move slowly to the left, while it was also observed that synchronization was very unstable.

(5) After four minutes, synchronization would be stable, the rate of the "flashing" effect would go down to approximately 1 cycle per 5 seconds, but the whole picture would now rapidly oscillate between two fixed positions on the screen; i.e., it appeared as if the horizontal centering control was rapidly turned back and forth at a rate of approximately 5 cycles per second. This rate would slowly diminish until it stopped, and after five minutes, at which time the bomb was at approximately 2000 feet altitude, the picture was stable again.

Many experiments were carried out using other airplanes installed with television transmitters in the role of glide bombs to observe these effects more closely. These airplanes were made to dive at a simulated target at the correct speed, while the control airplane made observations. By analysis of the motion-picture films

taken from the screen, it was thought that the vertical black bar was a result of the reflected blanking pulse, while all other effects could be traced to reflections. A typical example of such a test is given to indicate the nature of these reflections. In this test the airplane made a 180-degree turn immediately upon dropping the

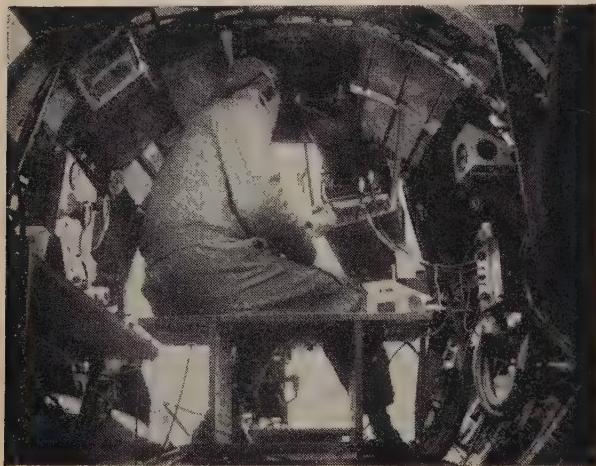


Fig. 61—Control position in nose of B-17 airplane; monitor unit BC-1214-A provides television picture for radio-control pilot.

"bomb" (in this case another B-17 with a complete television-transmitting installation) and the dive was completed in five minutes. The same effects were observed as were described above.

In Fig. 66 it can be shown that the difference in path

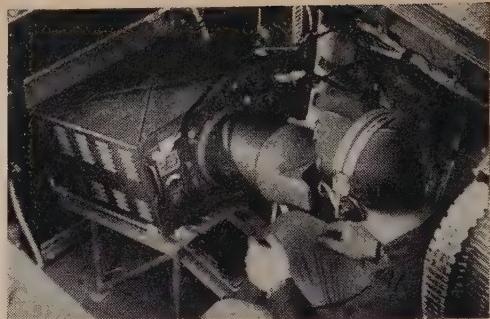


Fig. 62—Receiver installed in radio compartment of B-17 airplane. The television operator monitors synchronizing, contrast, and carrier controls.

length between the direct and the reflected wave is

$$X_d = \frac{(h_1 + h_2)}{\sin \alpha} \left[1 - \sqrt{1 - \frac{4h_1 h_2 \sin^2 \alpha}{(h_1 + h_2)^2}} \right]$$

while the angle between the reflected wave and the



Fig. 63—B-17 airplane carrying two GB-4 glide bombs on tactical mission over Europe.



Fig. 64—GB-4 glide bomb just after drop away from B-17 airplane.

ground surface can be expressed as follows:

$$\tan \alpha = \sqrt{\frac{(h_1 + h_2)^2}{d^2 - (h_1 - h_2)^2}}.$$

Substituting the flight data for this particular flight, a graphical representation is shown in Figs. 67 and 68. It was observed that the picture was reasonably useful after three minutes on this particular flight, which corresponds to an X_d of approximately 3000 feet and an angle α of approximately 15 degrees.

An analysis of the problem shows that reflections can become a serious detriment when the following conditions prevail:

- (1) The ratio of direct signal strength to reflected signal strength is low.
- (2) The distance X_d is larger than approximately 3000 feet, or roughly 20 per cent of the blanking pedestal.
- (3) The reflection angle α is larger than approximately 15 degrees.

This explains why these reflection phenomena were never observed when glide bombs were dropped from altitudes of 6000 feet or less. Just after bomb release, the ratio of direct signal strength to reflected signal strength will be high. When glide bombs are dropped over water, the signal strength of the reflected signal at the receiver will be high, effectively keeping the ratio of direct to reflected signal strength low. In the case of the drops from 6000 feet, as soon as this ratio had diminished to a point

where reflections could be expected, the value of X_d and α was so low that the reflected wave was further attenuated to a point where it was ineffective.

Inasmuch as it is impossible to control conditions (2) and (3) in the dropping of glide bombs, a solution to the problem was found by keeping the ratio of direct to reflected signal strength as high as possible. This was done by mounting the television receiving antenna on top of the

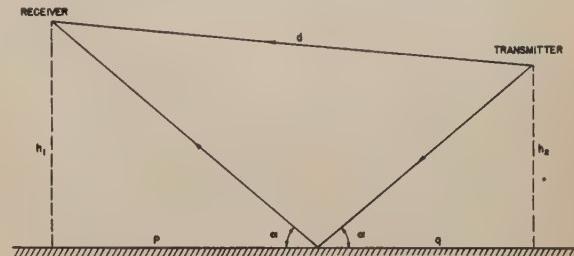


Fig. 66—Geometrical relationship between direct and reflected wave. the horizontal stabilizer of the control airplane in such a manner that the line between the top of the receiving antenna and the trailing edge of the stabilizer resulted in an angle of 12 degrees with the horizontal in normal flight. This angle corresponded to the angle (see Fig. 66) between the line "receiver-transmitter" and the horizontal, after three minutes of flight. This solution was so successful that no further difficulties were encountered with this reflection problem.

A series of frames from a motion-picture film, taken

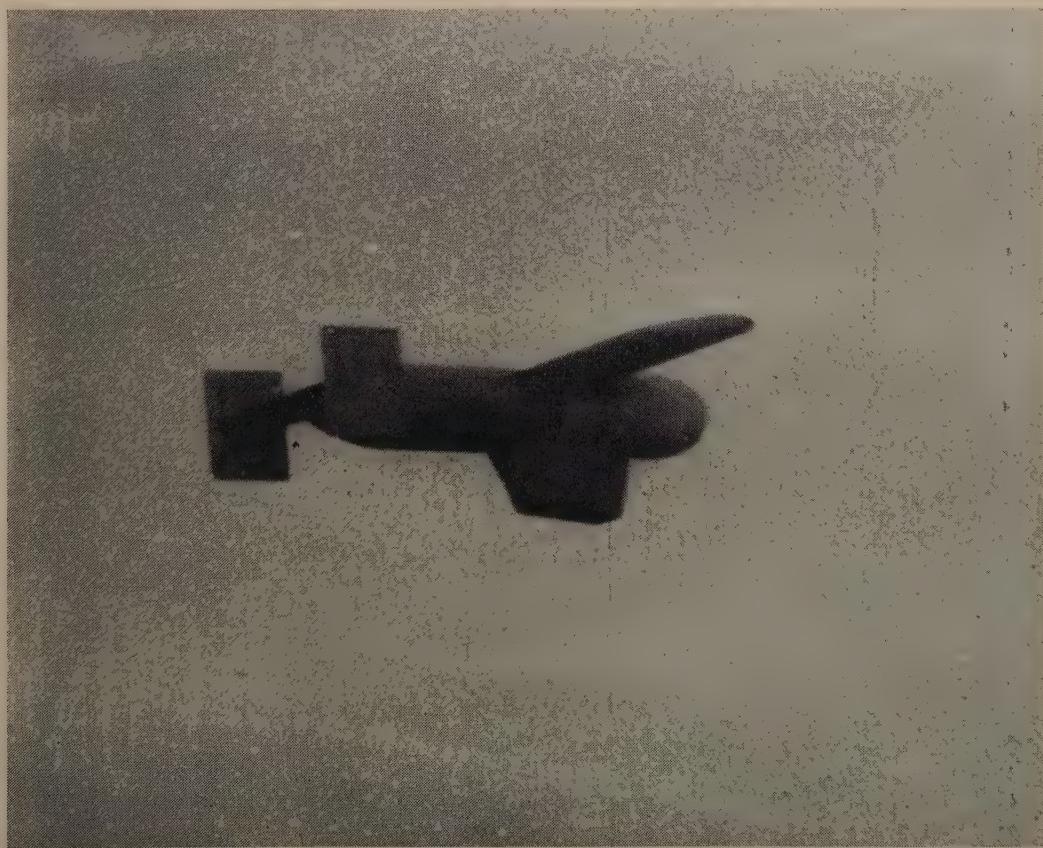


Fig. 65—GB-4 glide bomb on its way to the target. Note that the television camera is tilted downward because of the flight attitude of the bomb.

from the television screen on one raid, is shown in Fig. 69. The particular iconoscope used in this camera had a number of small spots on the mosaic which can be seen all through the picture. The target was located in a small village, identified by the dark woods which can be seen clearly in the background of the second picture of Fig. 69. A large white church and several houses are clearly

approximately 50 per cent as effective as the direct picture seen by the human eye. In addition, the small angle under which the target is viewed makes haze interference a serious problem. Therefore, it is imperative that targets can be easily identified in the picture by being located near prominent landmarks, such as the one illustrated in Fig. 71.

The development work described in this paper was performed during the period from 1941 to 1944, inclusive.

CONCLUSIONS

In conclusion, it may be said that airplane-to-airplane transmissions of television pictures are feasible. Many difficulties still may be encountered, but in general, successful transmission may be accomplished if the following precautions are observed:

(1) Transmitting equipment must be protected from interference produced by acoustical noises encountered in aircraft. Receiving equipment must be protected from interference produced by electrical noises encountered in aircraft.

(2) A stable master oscillator must be used in the transmitter, preferably followed by a buffer stage, in order to keep the frequency deviation due to frequency modulation less than the picture-line frequency.

(3) The ratio of direct-to-reflected signal strength in the receiving airplane must be kept as high as possible.

Compact lightweight television equipment can be used in guided missiles, and clear pictures, free from all interference, can be obtained if the aforementioned points are heeded.

(4) The contrast of the viewed scene must be high and possible targets should be located close to prominent landmarks so that they can be located easily.

ACKNOWLEDGMENT

The material in this article represents the efforts of many engineers, in addition to those of the authors. In particular, much credit is due the engineers of the RCA-Victor Division of the Radio Corporation of America for the original design and to the engineers of RCA and the Farnsworth Television and Radio Corporation for the solution of the many production problems. In addition, invaluable help was received from other members of the television development group, Radio Control Branch, Aircraft Radio Laboratory, and from the members of the Special Weapons Branch, Equipment Laboratory, Wright Field, who assisted in the field testing of this equipment. Many contributions to the art of using television equipment in guided missiles were made by the engineers of the Bureaus of Ships and of Aeronautics, Navy Department.

No small amount of assistance was provided by the National Defense Research Committee in the sponsorship of research endeavor which has resulted directly in the success of this development.

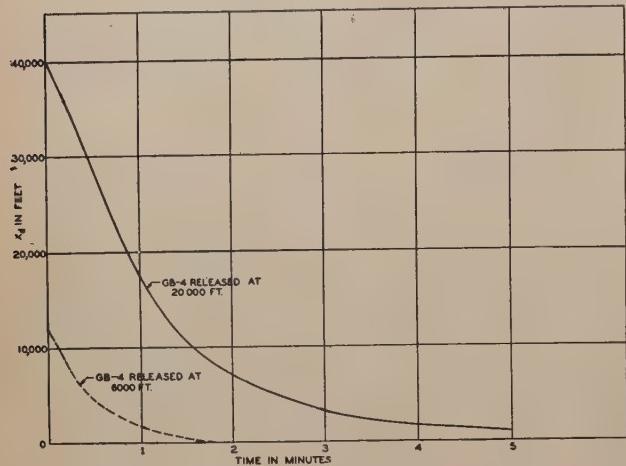


Fig. 67—Relationship between path difference and time after drop of GB-4 from B-17 aircraft at normal speeds. Release altitudes of 20,000 feet and 6000 feet.

visible as the bomb nears the target. Banking of the picture indicates that corrections to the flight path of the bomb are being given by radio control.

The question of target identification played an important role in selecting targets for guided missiles employ-

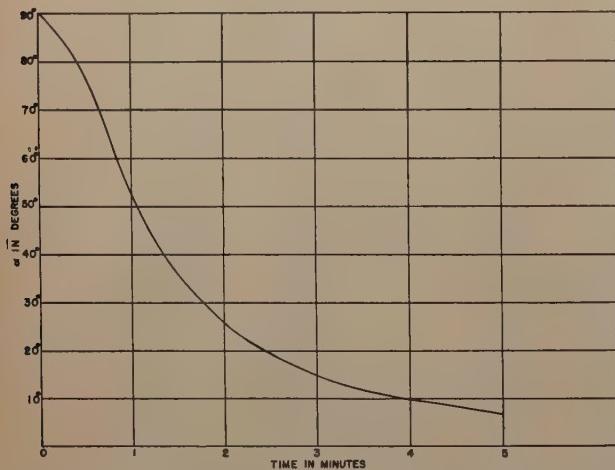


Fig. 68—Angle of reflected signal versus time for B-17 and GB-4 aircraft under the same conditions as described in Fig. 67.

ing television equipment. The submarine pens at Le Havre (see Fig. 71) and the installations on Helgoland (see Fig. 70) constitute an ideal target for guided missiles of this nature. The pens in Fig. 71 are located at the corner of an excellent landmark, the rectangular harbor basin, which can be seen from a great distance. In general, it was observed that the television picture is

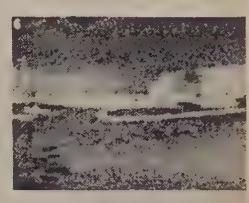


Fig. 69—A series of stills taken from motion-picture film showing glide bomb approaching target in Germany.

Fig. 70—A series of stills taken from motion-picture film showing the television screen of a "war-weary" missile approaching target at Helgoland, Germany. The island and harbor area can be seen. Observe compass course projection in lower-left-hand side of the picture. Also note antiaircraft fire in Frame 4.



Fig. 71—Reconnaissance photograph of a good target area for guided missiles. Because of the lower resolution, the television equipment would show only the major outlines or patterns.

The Cathode-Coupled Amplifier*

KEATS A. PULLEN, JR.[†], MEMBER, I.R.E.

Summary—This paper gives the reader a picture of the operation of the cathode-coupled amplifier and a study of methods of application in several new directions. Among these are the following: high-frequency amplifiers, multivibrators, audio oscillators, radio-frequency oscillators, resonant-resistance determination, mixers, and other applications.

This list is by no means all-inclusive, but does show some of the capabilities of this unique circuit.

I. INTRODUCTION

THE AUTHORS of the paper "Cathode-Coupled Wide-Band Amplifiers"¹ have made an excellent beginning in opening this interesting subject to the industry. They have pointed out a number of the properties of the unit and have indicated the extremely wide field in which this circuit will be found useful. The writer, for a number of months, has been experimenting with the same basic circuit, and has found a number of other forms in which the circuit is very valuable. Most of these properties have their basis in the extremely wide-band characteristics which result from the use of the high-impedance input existing in the cathode-follower tube and the combination of the shielding feature and impedance stabilization resulting from the use of the grounded-grid amplifier.

II. THE HIGH-FREQUENCY AMPLIFIER

The advantages of the cathode-coupled amplifier for high-frequency work result from the fact that the tuned circuit can be used at its full impedance instead of having to tap the coil for the input lead, as is necessary for use in ordinary circuits. If the grounded-grid amplifier alone is used, the coil or tuned circuit has to be tapped at a sufficiently low impedance that the input impedance is approximately the reciprocal of the mutual conductance. Otherwise, gain is lost by degeneration and by the fact that there is a limit to the plate-circuit impedance at these frequencies. If, for example, the plate-circuit capacitance is 2 micromicrofarads, and the plate-circuit Q is 50 micromicrofarads, with the frequency 100 megacycles, then the maximum impedance in the plate circuit will be the product of circuit Q multiplied by the capacitive reactance; namely, 800 times 50, or 40,000 ohms. As a grounded-grid amplifier, the effective amplification is reduced by the square root of the impedance transformation in the cathode or plate. For this stage to operate properly, it is necessary for the input impedance Z_i to be less than the cathode impedance Z_k and also small compared to $(R_p + Z_L)/(1 + \mu)$. (These formu-

las are verified in the Appendix.) The input impedance is thus required to be small. In the case of a 6J4 tube, for example, it would have to be less than 100 ohms. This requires tapping down the cathode input. The result is a voltage loss proportionate to the square root of the impedance ratio. If the tap were at 100 ohms, for instance, there would be a voltage step-down of 20 to 1. However, should the cathode-follower input circuit be used, the impedance step-down would be accomplished with a voltage loss of approximately 2 to 3. This gives an effective voltage gain of the cathode-follower stage of from 6 to 10. It must be noted that the series equivalent impedance of the cathode-follower stage is given approximately by the formula $Z = (Z_k + R_p)/\mu$. Hence, it is necessary that the cathode impedance in the circuit be small, or loss in the cathode-coupled stage would be experienced. This is the reason for choosing the cathode impedance approximately equal to the reciprocal of the mutual conductance. This also accounts for the impedance relation from cathode to plate in Section VIII, which follows. If the gain of the grounded-grid section were 20, therefore, the combination effective gain would be approximately 200, compared to 20 for the grounded-grid amplifier. The advantage of the cathode-coupled amplifier is shown in this application. The circuit appears in Fig. 1.

III. THE MULTIVIBRATOR

This circuit also makes a unique type of multivibrator. It is the only simple multivibrator having identical wave form on the two half cycles. This results from the fact that at no time is the cathode current cut off as a result of the cathode follower, nor is either grid conducting at any time. It is believed to be the most simple multivibrator with the widest range so far developed. With no difficulties, the circuit has been used, running free, at as high as 3 and 4 megacycles. A simple clipping operation will turn the stage into a square-wave generator. If so desired, the proportions of the two halves of the wave may be changed easily by placing the two grids at different direct potentials to ground. By biasing one grid to cutoff, a countermultivibrator can be made. Placing a differentiator circuit to pulse the blocked multivibrator causes the unit to trip over once for each positive or negative pulse. A direct-current microammeter will integrate the pulses and give a direct reading of pulse rate. This arrangement, in fact, can be made to do everything that the standard multivibrator will do, and a good many things not easily achieved by it. Uniquely enough, as can be noted in Fig. 2, in addition to a single capacitor and a single resistor in the frequency-determination circuit, only two resistors are required to make the unit.

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[†] The Pullen Laboratories, Brooklyn, N. Y.

¹ G. C. Sziklai and A. C. Schroeder, "Cathode-coupled wide-band amplifiers," Proc. I.R.E., vol. 33, pp. 701-709; October, 1945.

IV. THE AUDIO OSCILLATOR

A resistance-tuned audio oscillator can be built very simply by minor modifications of the multivibrator. The single resistor and capacitor are replaced by two resistors and two capacitors so arranged that one set is in series and the other in parallel. The feedback regulation, as can be seen in Fig. 3, is accomplished by placing a lamp bulb in the cathode circuit of the tube. Here, again, the extreme simplicity of the circuit is self-evident. The extra coupling circuit is eliminated, as are the parts usually supplying the screen. As in the case of the multivibrator, this oscillator operates with ease far beyond the normal

accomplished simply by introducing the alternating voltage on the normally grounded grid. The percentage of modulation possible without serious distortion is 50 per cent. A cathode follower supplying 10 volts is ample for this modulation. Little if any frequency modulation results, none being detectable on ordinary receiving equipment. However, no frequency-modulation equipment was available for confirmation of this fact. The crystal filter indicates the series of fixed peaks which would occur in the absence of frequency modulation. Operation of the oscillator in this form has been observed to frequencies as high as 158 megacycles. Even

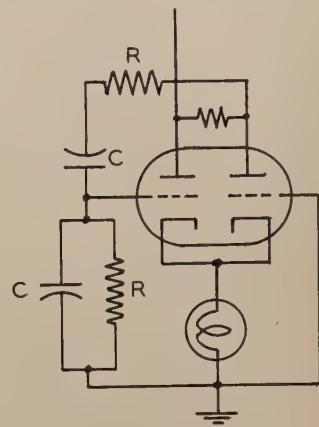
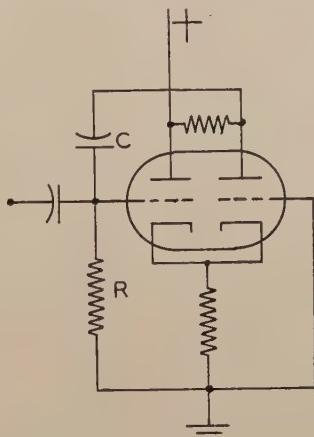
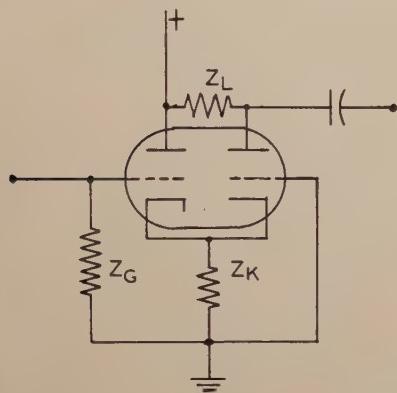


Fig. 1—Basic circuit of cathode-coupled amplifier. Fig. 2—The multivibrator circuit. Fig. 3—The resistance-capacitance oscillator circuit.

range of the ordinary resistance-tuned oscillator. These units have been operated satisfactorily at frequencies as high as 3 megacycles with excellent stability. With no voltage regulation, the frequency drift was found to be less than 1000 cycles at 1 megacycle. For extending the range into still higher frequencies, an additional cathode follower may be placed between the grounded-grid amplifier plate and the frequency-determining circuit. Interaction of that circuit on the system is then eliminated. However, stray capacitances should be watched in this case.

V. RADIO-FREQUENCY OSCILLATORS

There are several methods of making the circuit into an oscillator in addition to the one noted in the literature.¹ There are methods of using series-resonant circuits and methods of using parallel-resonant circuits. The simplest circuit, Fig. 4, and the one in general use in our laboratory, uses a type 6SN7 tube, with the common cathodes connected to ground through a 300-ohm resistor. The grounded-grid tube has a plate resistance of 10,000 ohms. A small capacitance, from 5 to 50 micro-microfarads, is placed from this plate to the cathode-follower grid. The tuned circuit is placed from grid to ground. The resulting oscillator has very high stability. At 1400 kilocycles it is within 500 cycles of final frequency within 25 seconds after being turned on. The frequency variation from line variations of ten per cent is of the order of 100 cycles. Modulation of the unit is

at this frequency, the oscillator did not drift more than ± 10 kilocycles at 40 megacycles. This implies a limit of about 40 kilocycles at 158 megacycles. Yet no voltage regulator was used, and there was no swamping capacitance to eliminate thermal effects.

The series-resonant circuit makes use of this element connected from grid to ground on the grounded-grid tube (Fig. 5). If the amplifier is so designed as to amplify the frequency of the resonant circuit, and the feedback circuit will pass the frequency, then oscillation takes place very readily. Little data are available on the characteristics of this circuit, as the other oscillator is of much more immediate use.

These circuits can be used for testing both series- and parallel-resonant circuits for oscillation, and also can be used in conjunction with a tuned circuit and calibrated variable capacitor for the measurement of dynamic circuit stray capacitance.

VI. RESONANT-RESISTANCE MEASUREMENTS

It is simple to set up a unit for measurement of quality of coils, capacitors, and tuned circuits with the oscillator design mentioned in the previous section. Application of a resistor in series with the feedback line to the tuned circuit stabilizes the combination so that results are reproducible. In this case, the cathodes are coupled by way of a variable resistance connected between them. The circuit is shown in Fig. 6. A grid-leak system is placed in series with the grounded grid for introduction

of a grid-current microammeter. Use of this as an oscillation indicator completes the unit. As noted, either coils, capacitors, or complete tuned circuits can be tested with this unit. The cathode control is calibrated directly in shunt resistance. It is desirable to use a pentode cathode-follower tube in order to minimize the input capacitance. The screen is by-passed to the cathode, eliminating the grid-to-screen capacitance.

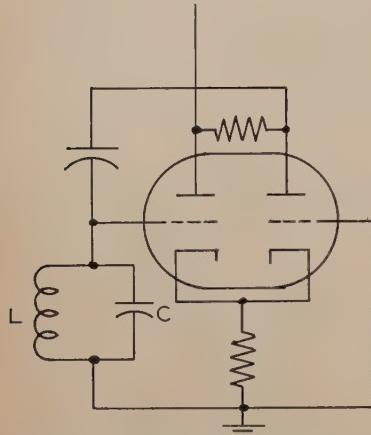


Fig. 4—The shunt-circuit oscillator.

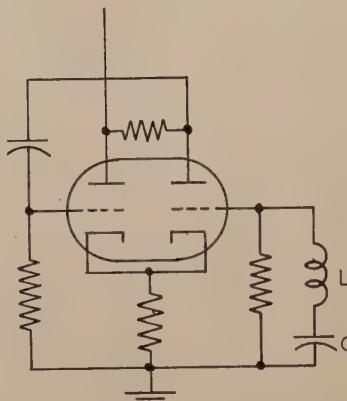


Fig. 5—The series-circuit oscillator.

IX. DESIGN DATA

A set of curves has been taken giving the voltage gain versus cathode-resistance value for three load resistances in this amplifier. These curves are plotted as taken

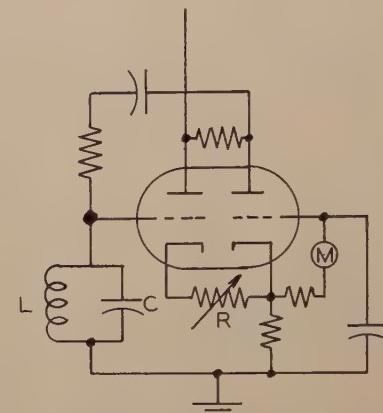


Fig. 6—The resonant-resistance meter.

VII. MIXERS

There are several methods of using this circuit as a mixer. The simplest method known to this writer is the injection of both the signal and the local oscillator into the input resonant circuit by way of a link coupling. (Fig. 7.) The grid circuit is coupled to the grid through a grid leak. This grid leak is of such a value as to permit passage of low frequencies up to the intermediate frequency. Then the cathode and plate circuits contain circuits tuned to the intermediate frequency and possess satisfactory impedance characteristics. The cathode circuit is high capacitance, and the plate low capacitance. This permits a good voltage gain in the stage.

VIII. OTHER APPLICATIONS

Most of the uses for the cathode-coupled amplifier so far mentioned operate with plate and cathode resistance. The arrangement can be used with impedances, such as tuned circuits, in these two positions. Proper application in this manner requires that the plate- and cathode-circuit impedances have the same type of frequency-impedance curves; or, in other words, the ratio of impedances of these two elements is independent of frequency. Then one has a wide-band high-frequency amplifier having a range of approximately 2 or 3 to 1 in frequency. Placing a small coupling capacitor from grounded-grid plate to cathode-follower grid on one of these amplifiers yields a basic oscillator which operates in the 100- to 200-megacycle range. This writer has had one operating on which he could connect any coil tuned between 80 and 210 megacycles and have the combination oscillate. Yet, without the input coil, no oscillation takes place. If the coil or tuned circuit placed in the grid

for a 6SN7 tube in Fig. 8. The curves can be reduced to per-unit curves applicable to any dual triode by remembering that, in the plate circuit, the comparison must be made to the plate conductance. Use of the proper scale on the amplification will make the data applicable to any dual triode of standard type. It should be noted that the greatest amplification is obtained when the cathode impedance is equal to approximately three halves of the reciprocal of the mutual conductance. Since the gain drops slowly above this value of impedance, an oscillator used with a tungsten lamp bulb in the cathode having a resistance sufficiently high will have a stabilizing action.

Using these curves on oscillators, it is necessary to assume a given input voltage on the input grid, and to adjust the plate resistance to that value which will give the voltage returned to the input grid at least slightly greater than the assumed starting voltage. Then the desired oscillation condition will develop.

In the audio oscillator, this requires a net minimum gain of 3+. This will permit establishment of oscillation if the shunt capacitances of the tube have reactances three or four times the parallel resistances.

In radio-frequency oscillators, the plate load resistance should be enough to produce a circuit gain of 4 or more. Then, as long as the reactance of the coupling capacitor is small, normal operation occurs. As long as the shunt resistance of the tuned circuit is greater than the minimum required to produce a returned unity gain, oscillation will occur. For this evaluation the tuned-circuit impedance is considered in parallel with the plate-load resistance. In practice, it is possible to make a 6SN7 tube oscillate at as high a frequency as 160

megacycles in this way. For this experiment, the total capacitance was the tube input capacitance.

Using this unit as a multivibrator, the same design conditions obtain. It is interesting to note that a single

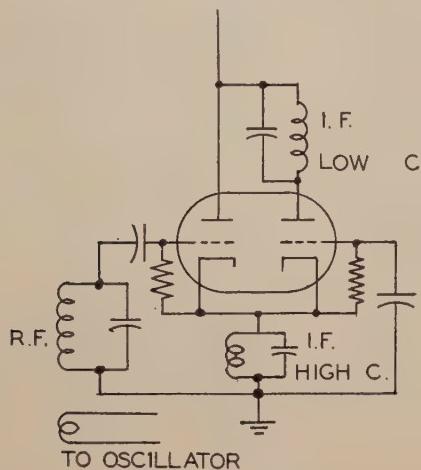


Fig. 7—The mixer circuit.

resistance and capacitance determine the frequency. As long as the total gain of the tube is over 1.5, multivibrator action will occur. The wave form is symmetrical, a unique condition for a multivibrator.

Using this unit as a wide-range amplifier, considerable care must be used if the signal amplitudes are large. The writer has found signal nonlinearity to be very troublesome under this condition.

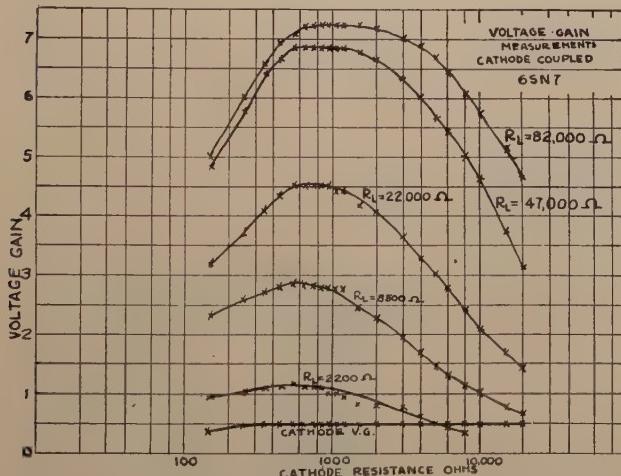


Fig. 8—Voltage-gain measurements of cathode-coupled 6SN7 tube.

X. CONCLUSIONS

As has been shown, this new cathode-coupled amplifier has an extremely wide usefulness. The methods of use are almost unlimited in scope. The writer feels that it may well become the basic circuit for almost all television, frequency-modulation, and related circuits, as well as one of the most valuable circuits for use in all types of electronic measuring equipment.

APPENDIX

The verification of the above-mentioned formulas for the grounded-grid amplifier is straightforward algebra.

(Fig. 9). Taking the input voltage as e_i , the input current as i_1 , the series impedance as Z_i , the cathode-circuit

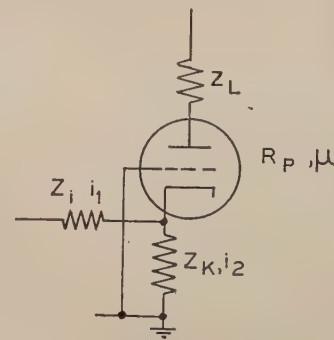


Fig. 9—Grounded grid amplifier.

impedance as Z_k , and the plate alternating current as i_2 , the first mesh equation is as follows:

$$e_i = i_1 Z_i + Z_k (i_1 + i_2).$$

Taking the plate load impedance as Z_L , the plate resistance as R_p , and the tube amplification factor as μ , the second equation is

$$[i_1 + i_2] Z_k \mu = i_2 (Z_k + R_p + Z_L) + i_1 Z_k.$$

Solving these two for the voltage gain, which is $i_2 Z_L / e_i$, the effective amplification is

$$e_0/e_i = \mu Z_L / [Z_i(1 + \mu) + (Z_i/Z_k + 1)(R_p + Z_k)].$$

From this equation, the above facts are readily recognizable.

Likewise, the effective internal impedance of the cathode follower as a source impedance is easily obtained (Fig. 10). Here the input voltage is e , the cathode

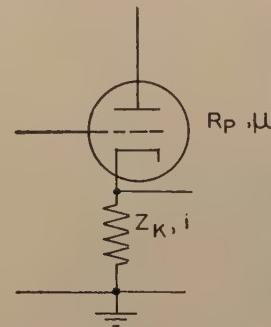


Fig. 10—Cathode follower.

impedance is Z_k , tube plate current is i_p , plate resistance is R_p , and the amplification factor is μ . Setting up the plate-current loop, remembering the voltage on the grid is the difference between e and $i_p Z_k$, the plate current becomes

$$i_p = e_i \mu / [(1 + \mu) Z_k + R_p].$$

Then subtracting voltage output from input gives circuit loss. This gives

$$e_{loss} = (Z_k + R_p) e_i / [Z_k(1 + \mu) + R_p]$$

as the voltage lost across a hypothetical series dropping resistance. Dividing this by i_p gives the expression

$$\text{loss impedance} = (Z_k + R_p) / \mu = Z_k / \mu + 1/g_m.$$

Contributors to Waves and Electrons Section



KEATS A. PULLEN, JR.

Keats A. Pullen, Jr. (M'46) was born at Onawa, Iowa, on November 12, 1916. He received the B.S. degree from California Institute of Technology in 1939. He engaged in advanced study at Johns Hopkins University between 1939 and 1943, doing considerable teaching and independent research during this period. A number of interesting electroacoustic developments resulted from this work. He engineered a depth-indicator unit for the Maritime Commission and a special depth indicator for the Navy while with Liberty Motors and Engineering Corporation, Baltimore, Maryland. Since 1945 he has been a special consultant in electroacoustics and electronics in New York City. He has a number of patents under preparation. He is a member of Sigma Xi, and the American Institute of Electrical Engineers.

*



LEONHARD KATZ

Leonhard Katz (M'44) was born in Vienna, Austria, on May 19, 1919. He received the B.S. degree in mechanical engineering from the Massachusetts Institute of Technology in 1941.

In 1942 he was assigned to the Radio Control Branch of the Aircraft Radio Laboratory, Wright Field, Dayton, Ohio, where he became project officer for the development and testing of airborne television and telemetering equipment. In 1944 he participated in the first airborne operations over the European Continent in which guided missiles using television equipment were employed. In 1945 he became project officer in the Radar Laboratory, Air Technical Service Command, Wright Field, and participated in a field investigation of the communications system of the German Air Force in Germany and Denmark.

He is at present employed as a development engineer at the Raytheon Manufacturing Company, Waltham, Mass.

*

E. Finley Carter (A'23-F'36) was born in Elgin, Texas, on July 1, 1901. He received the B.S. degree in electrical engineering from Rice Institute in 1922, and upon graduation became associated with the General Electric Company, engaged in radio development. In 1929 he became director of the radio division of the United Research Corporation in New York City, designing radios, circuits, and receivers.

Mr. Carter joined Sylvania Electric Products, Inc., as a consulting engineer in 1932, later becoming assistant chief engineer, and in 1941, was appointed to organize and head the industrial relations department. Mr. Carter is now vice president in charge of engineering of that organization.

He is an Associate member of the American Institute of Electrical Engineers, a member of the American Radio Relay League, and of Tau Beta Pi, and was a member of the Board of Directors of The Institute of Radio Engineers in 1944 and 1945.

*

Charles J. Marshall (J'31-A'33-SM'45) was born at San Antonio, Texas, on March 27, 1912. He received the B.S. degree in electrical engineering in 1939 from the University of Cincinnati Evening College.

Mr. Marshall was employed by the Crosley Corporation as a radio technician in the test department from 1929 to 1931; as a laboratory assistant in the inspection engineering department from 1931 to 1933; as an engineer-in-charge of vacuum-tube inspection from 1933 to 1937; and was in charge of all vendor-furnished electrical parts from 1938 to 1939. In 1939 he assisted



CHARLES J. MARSHALL

in the development and installation of the television studio and transmitter equipment of W8XCT.

He joined the engineering staff of the Aircraft Radio Laboratory, Signal Corps, at Wright Field, Dayton, Ohio, in 1939. From 1941 to 1943 he was project engineer for the design and testing of airborne television and telemetering equipment. From 1943 to 1944 he was chief engineer of radio-control, television, and telemetering projects. In 1945, Mr. Marshall was a development engineer on infrared equipment for the Special Projects Laboratory of the Air Service Technical Service Command. He is now chief engineer of the Special Development Branch, Aircraft Radiation Laboratory, Electronic Subdivision, Air Materiel Command, at Wright Field.

*



E. FINLEY CARTER

Abstracts and References

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ACOUSTICS AND AUDIO FREQUENCIES

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Push-Pull Frequency Modulated Circuit and Its Application to Vibratory Systems—A. Badmaieff. (*Jour. Soc. Mot. Pict. Eng.*, vol. 46, pp. 37-51; January, 1946.) A circuit in which the push-pull action is accomplished by using two capacitors with a common plate to vary the resonant frequencies of oscillator and discriminator in opposite phase relation. This circuit can be used for measuring vibrations or for monitoring purposes if the common plate is the moving element of a vibratory system. For application to the calibration of gramophone recording heads, see 3548 of 1945 (Roys).

534.121.1 1145
The Fundamental Frequency of Vibration of Rectangular Wood and Plywood Plates—R. F. S. Hearmon. (*Proc. Phys.*

Soc., vol. 58, pp. 78-92; January, 1946.) Results of theoretical and experimental investigation.

534.321.9 1146
Ultrasonic Interference at Angular Reflection—G. W. Willard. (*Phys. Rev.*, vol. 68, p. 284; December 1-15, 1945.) Abstract of an American Physical Society paper.

534.321.9: 538.652 1147
Magnetostrictive Oscillator Coupling—H. Thiede. (*Elec. Ind.*, vol. 5, p. 96; January, 1946.) A piston coupler of ceramic allows the application of a magnetostrictive oscillator under circumstances beyond its normal operative range, such as ultrasonic excitation of liquids (acids or bases) up to 700 degrees centigrade. Abstract of a paper in *Akust. Zeit.*, vol. 8, no. 1.

534.321.9: 620.179 1148
Supersonic Flaw Detector—R. B. De Lano, Jr. (*Electronics*, vol. 19, pp. 132-136; January, 1946.) The radar principle of pulse reflection from discontinuities is used with longitudinal supersonic waves of frequency 0.5 to 12 megacycles per second. Pulses, a few microseconds long, and with a 60-cycle-per-second repetition rate, are applied by a quartz-crystal transducer to the material under test, efficient coupling being obtained by a film of liquid. The same crystal serves as a pickup for the reflected pulse, which is amplified and displayed on a cathode-ray tube with an exponential time base and time marks, enabling the depth of the discontinuity to be measured.

The supersonic characteristics of various materials and pictorial examples of the performance of the instrument are given. See also 822 of April (Firestone).

534.321.9: 620.179 1149
Ultrasonic Vibrations Reveal Hidden Flaws—(*Elec. Ind.*, vol. 5, pp. 64-166; January, 1946.) Supersonic waves (50 kilocycles per second to 1 megacycle per second) are transmitted from a crystal vibrator to a crystal microphone through a moving strip or sheet to be tested. A flaw causes a change in attenuation, and the change in the received signal actuates a relay. The arrangement is useful for examining extruded products.

534.41 + 534.781 1150
Visible Speech Patterns Transmit Intelligence—(*Electronics*, vol. 19, pp. 200-202; January, 1946.) A short account of 823 of April (Potter).

534.42 1151
Electronic Sound Effects Circuit—H. Syzling. (*Electronics*, vol. 19, pp. 214-220; January, 1946.) Description of a battle-sound generator giving an output of 200 watts with automatic operation. Circuits for generating the sounds of near and distant shell bursts, machine guns, etc., are briefly described.

534.43: 621.395.61 1152

FM Phonograph Reproducer—W. Hausz. (*Elec. Ind.*, vol. 5, p. 106; February, 1946.) A capacitive pickup unit. The needle vibrations vary the frequencies of two high-frequency oscillators in push-pull, and the frequency-modulated difference frequency is filtered and detected. The mechanical design reduces the effects of eccentric records. Summary of U.S. Patent 2,386,049.

534.43: 621.395.61 1153

New Vibrating Reed Magnetic Pickup—R. G. Leitner. (*Radio*, vol. 29, pp. 25-63; December, 1945.) Design and construction. Output 2.5 millivolts at 1000 cycles per second. Cutoff 6000 cycles per second, but a special broadcast model cuts off at 12,000 cycles per second.

534.43: 621.395.61 1154

[Gramophone] Pickup with Low Mechanical Impedance—H. P. Kalmus. (*Electronics*, vol. 19, pp. 140-145; January, 1946.) Amplitude modulation of a 2.5-megacycle-per-second oscillator is produced by the motion of a resistive vane which is coupled to the stylus and varies the *Q* of the oscillator circuit. The triode oscillator acts simultaneously as a detector and audio-frequency amplifier. High compliance and small mass of moving element result in low mechanical impedance, so that only 14 grams weight is needed for satisfactory tracking. The response falls sharply at 4000 to 5000 cycles per second.

534.845: 534.373 1155

The Application of the Helmholtz Resonator to the Measurement of Sound Absorption—W. S. Tucker. (*Phil. Mag.*, vol. 36, pp. 473-485; July, 1945.) The resonance curve of a Helmholtz resonator excited by a sound field depends on, among other factors, the absorbing power of its walls. In the experiments described this fact was utilized to determine the absorbing power of porous earthenware over the range 150 to 600 cycles per second. A hot-wire (Tucker) microphone, located in the open mouth of the resonator, was used as the detector.

534.845: 677.521 1156

A Discussion of the Acoustical Properties of Fiberglas—W. M. Rees and R. B. Taylor. (*Jour. Soc. Mot. Pic. Eng.*, vol. 46, pp. 52-63; January, 1946.) The absorbing properties are discussed, with particular reference to aircraft sound insulation. Absorption tables for frequencies up to 4000 cycles per second are given.

534.862.6 1157

Intermodulation Distortion of Low Frequencies in Sound Film Recording—F. G. Albin. (*Jour. Soc. Mot. Pic. Eng.*, vol. 46, pp. 4-16; January, 1946.) An account of the phenomenon in variable-density recording, due to the photographic process.

in the region where the series section cannot yield a match. If an additional section of line is added between the matching section and the load, then both sections can be made to match any load.

- 621.396.11 + 621.396.82 1179
Notes on the Reception of Vertically Polarized Electromagnetic Waves; Some Notes on Circuit Shielding—(*Radio*, vol. 29, pp. 39-40; December, 1945.) A radio design work sheet.

- 621.396.67 1180
Three New Antenna Types and Their Applications—A. G. Kandoian. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 1, pp. 70W-75W; February, 1946.) All are primarily for very-high-frequency and ultra-high-frequency operation. Their radiation is substantially omnidirectional in the horizontal plane. A disk and cone type has a high-pass cutoff frequency above which the input impedance varies little over a 5:1 frequency range. A coaxially fed horizontal loop ("magnetic dipole") can be designed to match a coaxial line of, e.g., 50-, 70-, 100-ohm characteristic impedance at a particular frequency. An "electric-magnetic dipole" consisting of a coaxially fed horizontal loop with a vertical radiator rising from its center gives an elliptically polarized field distributed roughly as for an ordinary $\lambda/2$ dipole. It may be useful for counteracting severe fading conditions, when vertical and horizontal field components will probably not vary at the same rate. Constructional details of all types are shown, and the applications, singly and in multiple arrays, are discussed.

- 621.396.67 1181
Remote Tuned Antenna—(*Elec. Ind.*, vol. 5, p. 77; February, 1946.) A motor operates the telescopic arms of a rotatable horizontal dipole, to cover a range 46.5 to 215 megacycles per second.

- 621.396.67 1182
Currents in Aerials and High-Frequency Networks [Book Review]—F. B. Piddock. Oxford University Press, London, England, 8s. 6d. (*Wireless Eng.*, vol. 23, p. 90; March, 1946.) "The book is of an ultramathematical character."

CIRCUITS

- 621.3.011.2.012 1183
Impedance-Admittance Conversion Chart—R. C. Paine. (*Electronics*, vol. 19, p. 162; January, 1946.) Simple chart for converting $Z = R \pm jX$ to $Y = G \mp jB$ and vice versa.

- 621.3.017: 621.3.012.3 1184
Loss Due to Shunt Resistance Inserted Between Matched Source and Sink—(*Radio*, vol. 29, p. 37; December, 1945.) A design chart.

- 621.314.12 1185
D.C. Amplifier Coupling—P. K. Chatterjee and C. T. Scully. (*Elec. Ind.*, vol. 5, p. 118; January, 1946.) The use of a nonlinear resistance element, such as a thermistor, permits the transmission of a large proportion of a voltage change from an anode to a grid, without transmitting a corresponding proportion of the mean anode potential. Summary of U.S. Patent 2,383,710.

621.318.572: 621.385.38 1186

Pulse Response of Thyratron Grid-Control Circuits—C. H. Gleason and C. Beckman. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 34, pp. 71P-77P; February, 1946.) Advantages of peaked-waveform grid signals are discussed, and graphs given from which the influence of grid-circuit components on the grid-potential wave form can be predicted for several commonly used signal wave forms. The analysis is based on the assumption that the thyratron presents a relatively high impedance to the grid circuit, and the effect of grid current during the period prior to the initiation of the discharge is examined. In many cases the grid current is reasonably constant over a considerable range of negative grid voltage, and the correction required to take account of it amounts to a shift in the direct-current bias value.

621.385.2/.5].012.8 1187

Valve Equivalent Circuit—H. Biefer. (*Wireless Eng.*, vol. 23, pp. 91-92; March, 1946.) In vacuum-tube-circuit analysis, ambiguity can be avoided in the derivation of an equivalent circuit by attaching a definite sign to both current and voltage symbols. Comment on 3505 of 1945 (G.W.O.H.).

621.392.52 1188

Transient Response of Filters [Part II]—D. G. Tucker. (*Wireless Eng.*, vol. 23, pp. 84-90; March, 1946.) The method given in part I (870 of April) for the analysis of the transient response of multistage filters is inapplicable to single-section filters, and a new method of approach, using operational methods, is given. The build-up and decay envelopes of a single-section filter, used between resistance terminations equal to its design resistance, are analyzed, and the results compared with oscillographic records. The effects of slight variations in signal frequency are determined empirically by oscillographic methods.

621.394/.397].645 1189

Cathode-Follower Dangers: Output Circuit Capacitance—W. T. Cocking. (*Wireless World*, vol. 52, pp. 79-82; March, 1946.) It is shown that the particular advantages of the cathode-follower circuit are not maintained at frequencies so high that the time constant of the cathode circuit becomes significant. Very great care is needed in the design of cathode-follower circuits for television and radar frequencies, because the feedback feature accentuates the distortion effect of this time constant on pulse shape, and the effects of momentary cutoff of anode current by excessive input. "... so far from the cathode follower being able, by virtue of its low output resistance, to feed a circuit of high capacitance, it is usually necessary to restrict the capacitance to the lowest possible value."

621.394/.397].645.2 1190

Wide-Band Amplifiers—**1. Single-Circuit RF and IF Couplings: Coincidence Tuning**—(*Wireless World*, vol. 52, pp. 90-92; March, 1946.) General principles and detailed design formulas for wide-band couplings consisting of two circuits individually tuned to the same frequency.

621.394/.397].645: 621.396.822 1191

Noise Factor of Valve Amplifiers—N. R. Campbell, V. J. Francis, and E. G. Janes. (*Wireless Eng.*, vol. 23, pp. 74-83; March, 1946.) Conclusions of earlier papers are restated and applied to the design of vacuum-tube amplifiers. General formulas for the noise and gain of an amplifier stage are used to derive particular formulas for the common-grid triode and the common-cathode pentode, account being taken of lead inductances and interelectrode capacitances. Properties of perfect and dissipative four-terminal passive networks are discussed. The results are used to determine the effect on signal-to-noise ratio of the addition of extra stages to a cascade amplifier. The first of two parts. See also 1037 of April (Campbell and Francis) and 2918 of 1945 (Campbell, Francis, and James).

621.394/.397].645.3 1192

Negative Feedback—**1. "Cathode Ray"**—(*Wireless World*, vol. 52, pp. 41-44; February, 1946.) A simple explanation of the principle of negative feedback in amplifiers, dealing particularly with the difference between current and voltage feedback and their effects on the apparent internal resistance of the vacuum tube, considered in relation to the output load. For part 2, see 1193.

621.394/.397].645.3 1193

Negative Feedback—**2. Its Effect on Optimum Load and on Distortion—"Cathode Ray"**—(*Wireless World*, vol. 52, pp. 76-78; March, 1946.) For part 1 see 1192. The present article gives a graphical demonstration of the reduction of distortion by negative feedback, and explains why the best load resistance does not differ materially from that appropriate to the same vacuum tube without feedback.

621.394/.397].645.3: 621.314.25 1194

Phase-Inverter Circuit—C. B. Fisher and D. L. Drukey. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 34, p. 92P; February, 1946.) An application of the circuit described by Drukey (3846 of 1945). A high degree of balance and independence of tube characteristics is obtained, together with suppression of hum, tube noise, or distortion produced in the driver stage. A circuit diagram is given with component values.

621.394/.397].645.3: 621.314.25 1195

An Analysis of Three Self-Balancing Phase Inverters—M. S. Wheeler. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 34, pp. 67P-70P; February, 1946.) "A self-balancing phase inverter is a circuit converting one driving voltage to two output voltages of opposite phase but of essentially equal magnitude by an inherent characteristic of the device and not by virtue of any critical adjustment. The algebraic solution of three self-balancing phase inverters is given, assuming all circuit elements are linear. Included in the solution are the conditions for self-balance, the balance ratio, and the voltage gain. From this information, the type of inverter for a particular service may be selected and designed."

621.395.44: 621.395.645 1196

Carrier-Frequency Amplifiers: Transient Response with De-tuned Carrier—C. C.

Eaglesfield. (*Wireless Eng.*, vol. 23, pp. 67-74; March, 1946.) An analysis by operational methods of the transient response of an amplifier whose central frequency may differ from the carrier frequency. The importance of the depth of modulation of the test input wave form is investigated, and reasons are given for making it small. Numerical solutions are given for typical arrangements of a chain of eight stages. See also 68 of January (Eaglesfield).

621.395.645.29 1197
A Cathode-Coupled [a.f.] Isolating Amplifier—E. Travis. (*Electronics*, vol. 19, pp. 202-204; January, 1946.)

621.395.645.3 1198
An Analysis of the Comparison of Beam Power and Triode Tubes Used in Power Amplifiers for Driving Loudspeakers—Hilliard. (See 1166.)

621.395.645.3 1199
Bridging Amplifier for F-M Monitoring—G. E. Beggs, Jr. (*Electronics*, vol. 19, pp. 152-155; January, 1946.) The amplifier uses push-pull triodes throughout. The input stage is followed by a driver with a five-step gain control. Transformer coupling to the output stage is used, with negative feedback from output anodes to driven cathodes. A uniform response within ± 0.5 decibel, with 15 watts output for 0.3 volt root-mean-square input is obtained over the frequency range 20 cycles per second to 25 kilocycles per second, and the signal-to-noise ratio at maximum output is about 80 decibels. The amplifier is designed for use with a balanced input but may be used with a single-ended input by earthing the unused grid.

621.395.645.36 1200
Quality Amplifiers—(*Wireless World*, vol. 52, p. 61; February, 1946.) Correction to a circuit in 838 of April.

621.395.665 1201
Mixing Crystal Microphones—Patchett. (See 1169.)

621.396.11+621.396.82 1202
Notes on the Reception of Vertically Polarized Electromagnetic Waves; Some Notes on Circuit Shielding—(*Radio*, vol. 29, pp. 39-40; December, 1945.) A radio design work sheet.

621.396.611.1 1203
The Series and Parallel Components of Impedance—W. N. Tuttle. (*Gen. Rad. Exp.*, vol. 20, pp. 1-3; January, 1946.) Equations relating the series and parallel components of an impedance are applied to the case of parallel resonant circuits with high coil losses.

621.396.611.1.012.3 1204
Nomogram for Frequency Formula [$f = 1/(2\pi\sqrt{LC})$]—C. P. Nachod. (*Elec. Eng. N.Y.*, vol. 64, p. 469; December, 1945.)

621.396.611.21 1205
Electrodynanic Theory of Piezoelectric Oscillations—W. F. G. Swann. (*Phys. Rev.*, vol. 68, p. 282; December 1-15, 1945.) The problem is that of an X-cut crystal with self-induction and resistance in series, and vibrating with its two ends in different media. It is solved on the basis of Maxwell's

general dynamical theory. Abstract of an American Physical Society paper.

621.396.611.21: 621.396.662.34 1206
Crystal Filter Theory—F. J. Lehany and K. G. Dean. (*Radio*, vol. 29, pp. 8, 16; December, 1945.) Illustrated summary of 3820 of 1945.

621.396.615 1207
A New Type of Electrical Resonance—E. E. Schneider. (*Phil. Mag.*, vol. 36, pp. 371-392; June, 1945.) Utilization of phase inversion in a vacuum tube leads to a method of obtaining resonance with circuits containing only resistance and capacitance or resistance and inductance. Such circuits are compared with known resistance-capacitance oscillatory circuits, and the properties of reactance vacuum-tube networks are discussed and analyzed in detail. Experimental response curves are given for single and coupled resistance-capacitance circuits at very low frequencies.

621.396.615.14.029.62/.63 1208
Asymmetrical Butterfly Circuit—A. Landman. (PROC. I.R.E. AND WAVES AND ELECTRONS, vol. 34, p. 92P; February, 1946.) A circuit of good stability, using an RL 16 tube. The frequency range of the oscillator is restricted, in this case, to 290 to 350 megacycles per second. See also 3260 of 1945 (Karplus) and 1209.

621.396.615.14.029.63 1209
Coaxial Modification of the Butterfly Circuit—E. E. Gross. (*Electronics*, vol. 19, pp. 222-226; January, 1946.) Another abstract of the Institute of Radio Engineers paper; see also 883 of April.

621.396.615.17 1210
A New Pulse Generator Circuit—B. M. Banerjee. (*Indian Jour. Phys.*, vol. 19, pp. 75-82; June, 1945.) For many purposes, in particular for testing Geiger-Müller tube circuits, accurate synchronization between a pulse generator and a cathode-ray-tube time base is needed. This is achieved by the generation of a separately available synchronizing pulse preceding the main pulse by a fixed time interval. The assembly has three main parts—an unsymmetrical multivibrator, a pair of pulse-generating networks, and a pair of pulse amplifiers biased beyond cutoff. The performance of the particular model described is: pulse repetition frequency, 2 cycles per second to 200 kilocycles per second; pulse separation, 2 microseconds to 0.25 second; pulse durations, main 1 microsecond to 100 microseconds; synchronization, 1 microsecond to 500 microseconds. These are all independently variable. The generator produces negative pulses, triangular, 12 volts peak. It is claimed that the generator is "a simple solution of all the radio sounding problems associated with ionospheric apparatus. It is therefore expected that it will find wide use in this field."

621.396.615.17: 621.384.6 1211
Betatron Pulsing System—I. Paul and T. J. Wang. (*Electronics*, vol. 19, pp. 156-160; January, 1946.) A circuit is described for producing high-power pulses for the orbit-shift coils of a betatron; it has other applications, e.g., resistance welding and stroboscopic illumination.

A square-wave generator obtained from the sinusoidal voltage of the betatron coils is followed by a differentiator and flip-flop pulse amplifier producing a positive pulse of about 70 volts amplitude. This is used to trigger a thyratron, which, suddenly discharging, fires an ignitron, which discharges a 60-microfarad capacitor through the orbit-shift coilss, giving a 1000-amperes peak pulse, about 40 microseconds long at half amplitude.

621.396.615.17: 621.397.3 1212
Television Sweep Oscillators—Noll. (See 1381.)

621.396.619.018.41: 534.1 1213
Push-Pull Frequency Modulated Circuit and Its Application to Vibratory Systems—Badmaieff. (See 1144.)

621.396.66 1214
Control and Recording with Floating Grid—E. L. Deeter. (*Electronics*, vol. 19, pp. 172-198; January, 1946.) A large alternating voltage is applied through a very small capacitance (about 0.2 micromicrofarad) to the top cap grid of a vacuum tube, normal grid leakage being avoided as far as possible. With a suitable voltage, the capacitance provides a sensitive control of the anode current, which may be made to work a relay or recorder.

621.38 1215
Electronics for Engineers [Book Review]—Markus and Zeluff. (See 1428.)

621.392: 621.3.015.33 1216
Pulsed Linear Networks [Book Review]—E. Frank. McGraw-Hill Book Co., New York, N. Y., 1945, 262 pp., \$3.00. (*Electronics*, vol. 19, pp. 348-350; January, 1946.) See also 582 of March.

GENERAL PHYSICS

530.12: 531.18 1217
Derivation of the Lorentz Transformations—H. E. Ives. (*Phil. Mag.*, vol. 36, pp. 392-403; June, 1945.) New derivation shows that the transformations can be obtained by imposing the laws of conservation of energy and momentum on radiation processes as developed by Maxwell's method. The solution of apparent conflicts demands the variation of mass with velocity, and the variation of linear dimensions and clock rate. The space and time concepts of Newton and Maxwell are retained without alteration.

530.12: 538.3 1218
Relativistic Interaction of Electrons on Podolsky's Generalized Quantum Electrodynamics—D. J. Montgomery. (*Phys. Rev.*, vol. 68, p. 287; December 1-15, 1945.) Extension of the basis for a generalized electrodynamics involving higher derivatives in the field equations formulated by Podolsky and Kikuchi (*Phys. Rev.*, 1944, vol. 65, p. 228, and 1945, vol. 67, p. 184). Results are applied to the relativistic interaction of two electrons. Abstract of an American Physical Society paper.

531.4+539.62+621.394.653+621.395.653 1219
The Physics of Rubbing Surfaces—F. P. Bowden. (*Jour. Roy. Soc. N.S.W.*, vol. 78, pp. 187-219; December 3, 1945.) A

comprehensive review of experimental information on the mechanism of frictional forces. The area of true contact is only a very small fraction ($\sim 10^{-4}$) of the total area of the apparently touching surfaces. The electrical conductance between two given materials is independent of the area of the apparently touching surfaces, and is little affected by their state of roughness; it depends mainly on the mechanical force between them. The deformation of the material at the points of true contact is mainly plastic rather than elastic.

The temperature at the true contact points when metals are rubbed together depends on load, speed of sliding, and thermal conductance, but can be very high. Polishing is mainly caused by melting at the contact points. A material with a high melting or softening point will polish a material that has a lower melting or softening point. The relative hardnesses at room temperature are unimportant.

Friction and surface damage of metals sliding very slowly so that contact temperature rise is not great depends on the relative hardnesses. The surface of the softer metal of a pair is ploughed out and torn; the harder surface is comparatively undamaged, but fragments of the softer metal are welded on to it; the damage to rubbing surfaces of similar homogeneous metals is more profound. Work hardening and deformation of rubbing metals occurs to a considerable depth below the actual track of the contact.

The theory of solid friction is examined. The use of metallic films as lubricants and the use of bearing alloys are discussed. The effect of naturally occurring films of oxide and other impurities on the reduction of friction between metal surfaces is shown to be very large.

534+538.56 1220
The Wave Equation in a Medium With a [Space-] Variable Index of Refraction—P. G. Bergmann. (*Phys. Rev.*, vol. 68, p. 286; December 1-15, 1945.) Abstract of an American Physical Society paper.

535.317: 621.397 1221
[Optical] Lens Aberrations in Picture Projection—Montani. (*See* 1379.)

535.43 1222
On the Theory of Light-Scattering—A Note—S. Parthasarathy. (*Phil. Mag.*, vol. 36, pp. 510-514; July, 1945.) A continuation of an argument with Krishnan (see 3334 of 1940). The writer claims that Krishnan's results "have been vitiated by grave errors" and gives detailed reasons.

537.221: 621.317.32 1223
A Modified Kelvin Method for Measuring Contact Potential Differences—Meyerhof and Miller. (*See* 1282.)

537.525 1224
Small Perturbations of the Electric Discharge—V. L. Granovsky. (*C. R. Acad. Sci. U.S.S.R.*, vol. 28, pp. 40-44; July 10, 1940. In English.) Equations were developed in a previous paper (*C. R. Acad. Sci. U.S.S.R.*, vol. 26, no. 9—Granovsky) describing the dynamic states of the plasma under diffusion conditions. In this paper conclusions are deduced from them for conditions of small perturbations. (a) The rela-

tions between the variable components of the discharge parameters do not depend on the external circuit. (b) The passage of a transient is aperiodic for gas pressures greater than a critical value, and damped oscillatory for lower pressures. (c) Forced oscillations (modulated discharge) are considered, and various semiquantitative conclusions reached on the relationship between the modulating electromotive force and the current, particle concentration, etc.

537.531(091) 1225
X-Rays, an Early Institute Topic—(*Elec. Eng.*, vol. 64, pp. 435-436; December, 1945.) Excerpts from papers delivered before the American Institute of Electrical Engineers in 1896 on theoretical and practical aspects of X rays.

537.533.8 1226
Erratum: Secondary Emission of Pyrex Glass—C. W. Mueller. (*Jour. Appl. Phys.*, vol. 17, p. 62; January, 1946.) Correction to the composition of the glass quoted in 3648 of 1945.

538.1 1227
Note on Magnetic Energy—E. A. Guggenheim. (*Phys. Rev.*, vol. 68, pp. 273-276; December 1-15, 1945.) A note to correlate the magnetic-energy equations obtained by Livens (2825 of 1945) with the author's previous results (3221 of 1936). These equations apply to any unique relation between *B* and *H* whereas those of Livens are based on "linear laws of induction." In the two cases considered by Livens, it is shown that the formulas only differ from the author's by constants.

538.569.4+621.396.11.029.64 1228
The Absorption of Microwaves by Gases—Hershberger. (*See* 1336.)

539.16.08 1229
Counters for Use in Nuclear Spectroscopy—M. L. Wiedenbeck. (*Rev. Sci. Instr.*, vol. 17, pp. 35-37; January, 1946.) A description of several self-quenching counters for counting conversion electrons with energies as low as 20,000 electron volts arising from an excitation process having a cross section of the order of 10^{-34} square centimeters.

539.16.08: 621.385.5 1230
Use of 6AK5 and 954 Tubes in Ionization Chamber Pulse Amplifiers—Parsegian. (*See* 1404.)

539.163.2.08 1231
The Theory of the 180° Magnetic Focusing Type of Beta Ray Spectrometer—A. K. Saha. (*Indian Jour. Phys.*, vol. 19, pp. 97-119; June, 1945. Development of an expression for the transmission factor as a function of the magnetic field and the electron momentum. It is illustrated by the complete calculation of the factor for the Lawson and Tyler spectrometer.

621.385.833 1232
Space-Charge-Limited Beams in Electrostatic Fields—Rose. (*See* 1313.)

5 1233
Science in Progress. Fourth Series [Book Review]—University Press, Yale, Oxford University Press, London, 331 pp., \$3.00. (*Proc. Phys. Soc.*, vol. 58, pp. 129-130;

January 1, 1946.) A set of eleven essays by eminent scientists, including one by Rabi on molecular beams and radio-frequency spectroscopy.

530.145.6 1234
Elementary Wave Mechanics [Book Review]—W. Heitler. Oxford University Press, London, 1945, 136 pp., 7s.6d. (*Proc. Phys. Soc.*, vol. 58, pp. 127-128; January 1, 1946.) "It is truly elementary, both in the demands which it makes on the previous knowledge and mathematical ability of the reader, and also in that it deals only with the elements of wave mechanics."

GEOPHYSICAL AND EXTRA-TERRESTRIAL PHENOMENA

523.746.5: 621.396.11: 551.51.053.5 1235
The New Sunspot Cycle—T. W. Bennington. (*Wireless World*, vol. 52, pp. 83-85; March, 1946.) The rise in the sunspot number from its minimum in 1944 has been unusually rapid. The next maximum may be considerably higher than the last. It may occur before May, 1948, or in 1949. The curves of 12-month running averages of sunspot numbers and of critical frequency show a remarkable parallelism and should enable the prediction of the long-period variation of these quantities for a short time ahead with great accuracy. The article gives very detailed anticipation of usable frequencies for various routes: e.g., "Frequencies up to 22 megacycles per second ought to be usable for good periods during the day in the early months [of 1946] for communication with the United States of America, falling to about 17 megacycles per second during the summer and increasing to about 29 megacycles per second next winter. When all the path is in darkness, 7 megacycles per second will at first be the highest safe frequency, but next summer frequencies up to 14 megacycles per second should be usable most of the night. By next winter 10 megacycles may be usable throughout the night."

550.38+551.594.5 1236
The Aurora and Geomagnetism—C. W. Gartlein. (*Elec. Ind.*, vol. 4, pp. 76-77; December, 1945.) An electron device now under development is expected to overcome the difficulty of observing weak auroral activity during the full-moon period. Closer correlation between solar and magnetic intensity observations is foreseen. A brief survey of the relation between sunspots and magnetic storms produced by currents in the upper atmosphere and their effect on communications. Summary of an Institute of Radio Engineers paper. See also *Electronics*, January, 1946, vol. 19, pp. 242-244.

550.38 1237
Secular Magnetic Variations as Transients—W. M. Elsasser. (*Phys. Rev.*, vol. 68, p. 285; December 1-15, 1945.) The higher-harmonic components of the earth's magnetic field are subject to secular variations within periods of the order of a few hundred years. The inductance of the earth's metallic core is large, and periods of spontaneous decay of currents in the core are calculated to be of the order of 10^4 to 10^5 years. Abstract of an American Physiological Society paper.

551.594.223

What Are Fireballs?—E. A. Logan. (*Elec. Rev.* (London), vol. 138, pp. 381–383; March 8, 1946.) It is suggested that fireballs (or ball lightning), which may be produced by cloud-to-cloud lightning, may be analogous to the vortex ring in structure.

LOCATION AND AIDS TO NAVIGATION

621.383

Photoelectric Aid for the Blind—(See 1309.)

621.396.82: 621.396.9

Radar Countermeasures—D. G. F. (See 1356.)

621.396[.9+.94]

A Note on the Detection of Undersea Craft by Means of Low Frequency Radiation from Aircraft—D. W. R. McKinley. (*Canad. Jour. Res.*, vol. 23, Sec. A, pp. 77–85; November, 1945.) “A semiquantitative examination is made of the chief factors affecting both the transmission of low-frequency radiation from an aircraft to a submarine and the return of this energy to the aircraft by scattering. A general expression is derived for the returning field strength, and graphs are shown for a representative set of conditions. It is indicated that, even under the most favorable conditions, the amount of energy returned is below the level of detectability, if the submarine is submerged more than 10 feet. However, it is also pointed out that communication between a shore station and an undersea craft should be feasible under certain conditions.”

621.396.9

Decca Navigator: Continuous-Wave Navigation System—(*Wireless World*, vol. 52, pp. 93–95; March, 1946.) Marine position finding by means of pulse transmissions is limited by the propagation characteristics of the very high frequencies implicit in the use of very short pulses. The Decca system uses continuous waves and can therefore take advantage of the more favorable ground-wave propagation characteristics of frequencies of the order of 100 kilocycles per second. For two synchronized transmitters, the loci of receiving points associated with given constant-phase differences are a family of hyperbolas. A third synchronized transmitter similarly determines another family of hyperbolas, and the ship can be located on the intersection of two hyperbolas by observations of the phase differences between the received signals. This is the essential theoretical basis of the Decca system. In practice, the master transmitter controls two remote phase-locked slave transmitters. The difficulty of distinguishing between three transmissions on the same frequency is overcome by using three different frequencies, each of which is a submultiple of the same higher frequency (e.g., 85 and 113.33 kilocycles per second, which are both submultiples of 340 kilocycles per second. The receiver receives each transmission separately and generates the appropriate harmonics for comparison of phase differences. This and other working details are described. See also 331 of February.

621.396.9

Principles of Loran in Position Location—R. W. Kenyon. (*Elec. Ind.*, vol. 4, pp.

1238

106–140; December, 1945.) See also 605 and 606 of March (D. G. F.).

621.396.9

The Future of Radar—L. A. Du Bridge. (*Elec. Ind.*, vol. 4, pp. 77, 80; December, 1945.) Sea and air navigation will be greatly improved by the use of loran (long-range navigation) systems and by new microwave systems over shorter ranges. Summary of an Institute of Radio Engineers paper. See also *Electronics*, vol. 19, pp. 254–256; January, 1946.

621.396.9

Fundamentals of Radar [4]—(*Wireless World*, vol. 52, p. 65; February, 1946.) Correction to 927 of April.

621.396.9

Radar in Merchant Ships—S. T. Allsop. (*Wireless World*, vol. 52, pp. 66–67; February, 1946.) General description of a compact set, easy to install and maintain, intended to give warnings of icebergs, other surface craft and, with its plan-position-indicator presentation, to show the position and outline of a coastline. The accuracy is about 2 degrees in bearing and 200 yards in range, with a maximum range of about 6 miles on a trawler target but considerably more for larger ships or for a coastline. Three plan-position-indicator displays are provided, one in the main chassis and two in remote positions convenient for navigation. Operating frequency evidently about 10,000 megacycles per second.

621.396.9

Navigational Radar: Experimental Equipment for Use in Merchant Ships—(*Wireless World*, vol. 52, p. 89; March, 1946.) A description of a demonstration of a centimeter-wave plan-position-indicator system. “A demonstration run of nearly an hour’s duration down one of the busiest shipping channels in the Thames Estuary showed that the ship could be conned with complete confidence through the traffic leaving ships and buoys a cable’s length on either hand. During the whole time, the navigator based his helm orders solely on information given by the plan-position-indicator display.”

621.396.9

SCR-545 Radar—(*Electronics*, vol. 19, p. 198; January, 1946.) Correction to data given in 612 of March.

621.396.9

Radar on 50 Centimeters—H. A. Zahl and J. W. Marchetti. (*Electronics*, vol. 19, pp. 98–104; January, 1946.) Description of the general arrangement, the aerial, and high-frequency system, of a light-weight 600-megacycle-per-second early warning radar type AN/TPS-3. Total weight, including generators and aerial, 1200 pounds. Range, 120 miles. The equipment can be erected by four men in half an hour. The transmitter uses a single VT158 pulsed at 200 cycles per second by a spark-gap modulator, and feeds an array of three dipoles with reflectors, mounted in the focal plane of a 10-foot-diameter paraboloid. The outer dipoles can be switched in or out of circuit to alter the coverage. The set gives range and azimuth only. Details are given of the rotating joint in the coaxial aerial feeder, and the transmit-receive system is illustrated. There

is A-scope and plan-position-indicator display. To be continued.

621.396.9

The [AN/] MPG-1 Radar—H. A. Straus, L. J. Rueger, C. A. Wert, S. J. Reisman, M. Taylor, R. J. Davis, and J. H. Taylor. (*Electronics*, vol. 19, pp. 110–117; January, 1946.) An account of the transmitting, radio-frequency receiver, and aerial systems of the 10,000-megacycle-per-second fire-control radar described in 610 of March. The modulator is of the hard-tube, capacitor-discharge type, with a pair of pulse transformers to enable the high-voltage pulse from the modulator to be taken by line to the magnetron. The stepup transformer has a double secondary connected to make the magnetron filament transformer remain at earth potential as the filament itself becomes highly negative. The radio-frequency system consists of a “squeeze box” standing-wave adjuster, transmit-receive, and anti-transmit-receive switches, directional coupler monitor, rotating feed, horn, and reflector. The squeeze box enables the greatest magnetron frequency stability to be obtained. The radiator consists of a folded horn with a parabolic cylinder as reflector, and produces a beam about 0.6 degree wide and 3 degrees high. The scanning system is described.

621.396.9: 061.6

History and Activities of the Radiation Laboratory of the Massachusetts Institute of Technology—L. A. DuBridge. (*Rev. Sci. Instr.*, vol. 17, pp. 1–5; January, 1946.) A wartime institution under the Office of Scientific Research and Development, set up to develop microwave radar.

621.396.9: 623.454.25

Radio Proximity Fuze—Trotter. (See 1326.)

621.396.933.2

Fundamentals of Radar: 5. Beacons Employing Pulse Technique—(*Wireless World*, vol. 52, pp. 55–56; February, 1946.) Radar beacons, developed from the identification-friend-or-foe system (3915 of 1945), with a transponder on the ground and an interrogator and responder in the aircraft, are used as homing and beam approach aids. With ranges up to 100 miles the aircraft may be within the working area of several beacons, so identification is given to each by interrupting the responses from the transponder. The equipment involved is simple, light, and cheap, and should be of great value in peacetime flying. See also 3914 of 1945.

621.396.933.2

Direction Finder—M. Nelson. (*Elec. Ind.*, vol. 5, pp. 120, 164; January, 1946.) “A Rotating radiation pattern is frequency modulated with a frequency identical [with], or an exact multiple of, the frequency of rotation of the beam. . . . Upon amplitude and frequency demodulation, two signals are obtained in the receiver, phase comparison of which indicates the position of the aircraft with respect to the transmitter station.” Summary of U. S. Patent 2,377,902.

621.396.933.23

Microwave Instrument Blind Landing System—Sperry Gyroscope Co. (*Elec. Ind.*,

vol. 5, pp. 60-136; February, 1946.) Equipment operating at 2617 megacycles per second. Two transmitters in separate trailers and operating 23 megacycles per second apart feed parabolic reflectors to produce the glide and localizer paths. The beams are switched at 60 cycles per second to produce intersecting lobes which are modulated at 600 and 900 cycles per second, respectively. The receiver has a mechanical indicator to give the position of the plane relative to the correct approach line.

621.396: 629.13 1256
Aviation Radio [Book Review]—H. W. Roberts. W. Morrow and Co., New York, N. Y., 1945, 637 pp., \$5.00. (*Elec. Ind.*, vol. 5, p. 162; February, 1946.) "A complete study of the subject usable both by the novice and the professional."

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788 1257
Calibration of Ionization Gauge for Different Gases—S. Dushman and A. H. Young. (*Phys. Rev.*, vol. 68, p. 278; December 1-15, 1945.) Preliminary notice, including a table of results, of calibrations for He, Ne, A, Kr, Xe, Hg, H₂, N₂.

533.5 1258
A Metal Packless Vacuum Valve—E. Topanelian, Jr., and N. D. Coggeshall. (*Rev. Sci. Instr.*, vol. 17, p. 38; January, 1946.) An all-metal vacuum tube requiring no sealing grease or lubricant. A steel needle connected to a movable bellows engages a brass sealing. Pipe-line connections are through Kovar-to-glass seals.

534.845: 677.521 1259
A Discussion of the Acoustical Properties of Fiberglas—Rees and Taylor. (*See* 1156.)

537.228.1 + 539.32 + 621.3.011.5]: [546.32.85 + 546.39.85 1260
The Elastic, Piezoelectric and Dielectric Constants of Potassium Dihydrogen Phosphate (KDP) and Ammonium Dihydrogen Phosphate (ADP)—W. P. Mason. (*Phys. Rev.*, vol. 68, p. 282; December 1-15, 1945.) Measurements have been made of all the elastic, piezoelectric, and dielectric constants of KDP and ADP crystals through temperature ranges down to the Curie temperatures. KDP behaves in accordance with theory, but ADP undergoes a transition at -125 degrees centigrade unconnected with the H₂PO₄ hydrogen bond system which controls the dielectric and piezoelectric properties. Abstract of an American Physical Society paper.

537.228.1 + 621.396.611.21 1261
The Acid Etching and Steam Treatment of Quartz Oscillator Plates—D. Fairweather. (*Marconi Rev.*, vol. 8, pp. 136-146; October/December, 1945.) The methods of finishing quartz oscillator plates to the desired frequency, for frequencies of 3 megacycles per second and higher, are examined critically. It is shown that for an etched plate $R = KF^2$, for constant etchant strength, where R is the rate of change of frequency, K is a constant, and F is the plate frequency. Steam treatment, with a similar law, has little value as a method of adjusting plates to frequency, but does provide an alternative method of aging and may be

used to test the effectiveness of the etching processes.

537.228.1 1262
Methods of Orienting and Cutting Synthetic Crystals—W. L. Bond. (*Phys. Rev.*, vol. 68, p. 282; December 1-15, 1945.) The methods include optically orienting on a mounting board, securing by fast-setting cement, grinding a reference face at a predetermined angle from the board edges, sawing with solution-cooled abrasive blades, and grinding to dimension with abrasive belts. The application of these to ADP is discussed. Abstract of an American Physical Society paper.

537.228.1 1263
Apparatus for Growing Single Crystals from Solution—A. N. Holden. (*Phys. Rev.*, vol. 68, p. 283; December 1-15, 1945.) Abstract of an American Physical Society paper.

537.228.1 1264
The Order of Magnitude of Piezoelectric Effects—H. Jaffe. (*Phys. Rev.*, vol. 68, p. 282; December 1-15, 1945.) Piezoelectric coefficients are given as figures of merit for the selection of different materials for various applications. For sound generators, pickups, and microphones, Rochelle salt is still preferable, but for ultrasonic work in liquids, synthetic crystals may be preferred. Abstract of American Physical Society paper.

537.228.1: 537.531.9: 549.514.1 1265
Relation Between Darkening by X-Ray Irradiation and Permanence of Dauphiné Twinning in Quartz—E. Armstrong. (*Phys. Rev.*, vol. 68, p. 282; December 1-15, 1945.) Quartz plates were subjected to inversion to the high-temperature form and reinversion to low quartz. Each plate was then irradiated with X rays from a copper target tube. There was positive correlation between the amount of darkening caused by the X-ray irradiation and the permanence of their Dauphiné twin boundaries when subjected to the inversion treatment. Abstract of an American Physical Society paper.

621.315.52 + 621.315.559]: 018.44 1266
The Electrical Resistance of Iron Wires and Permalloy Strips at Radiofrequencies—A. W. Smith, J. H. Gregory, and J. T. Lynn. (*Jour. Appl. Phys.*, vol. 17, pp. 33-36; January, 1946.) Substitution of test specimens of the materials in place of a series of standard resistors in a circuit resonant at the required radio frequency f (between 1.5 and 6 megacycles per second) enables the alternating-current resistance R of the specimens to be obtained by interpolation. Comparison with the direct-current resistance R_0 gives an empirical equation $R/R_0 = 0.4 + 1.5d(f\mu o/10^3)^{1/2}$ for iron wire and $R/R_0 = A + f(a/b)1.12(fab\mu o/10^3)^{1/2}$ for permalloy strip of dimensions $a \times b$. d = wire diameter (centimeters), f = frequency (megacycles per seconds), μ = permeability (gauss/orsted), o = conductivity (mhos per centimeter), A = empirical constant for each specimen, $f(a/b)$ = a function obtained from Cockcroft (1929 abstracts, page 224). These results are compared with existing theoretical work. "The relatively simple form of the empirical equation supports the hope that a definite physical meaning can be assigned to ... A and ... $f(a/b)$.

621.315.61 1267

Radio Insulating Materials: Part 4—A. H. Postle. (*Radio*, vol. 29, pp. 33-60; December, 1945.) Preparation and properties of compression-moulded and transfer-moulded glass-bonded mica (permittivity 7). Higher permittivity materials (ϵ up to 20) in moulded forms, and temperature compensating materials having permittivities up to 80 and a temperature capacitance coefficient of 1 in 10^3 are available. For part 3, see 632 of March.

621.315.613.1 1268

Electrical Properties of Indian Mica: II. The Effect of Varying Relative Humidity—P. C. Mahanti, M. K. Mukherjee, and P. B. Roy. (*Indian Jour. Phys.*, vol. 19, pp. 83-92; June, 1945.) A continuation of the work described in 3543 of 1943 (Datta, Gupta, and Mahanti). The measurement was by substitution by a standard air capacitor in a Schering bridge. Various methods of maintaining a known humidity in an enclosed space are described, including the use of saturated aqueous solutions of a range of salts such as calcium chloride, calcium sulphate, etc. The method chosen was the use of aqueous solutions of glycerin. This has the important advantage that the relative vapor pressure is substantially independent of temperature over the range 0 to 70 degrees centigrade, and that the solutions are easily standardized by measurement of refractive index. The results confirm those obtained by previous workers. The power factor begins to rise at about 40 per cent relative humidity and rises steeply beyond 80 per cent.

621.315.614: 621.315.615 1269

The Electrical Resistivity of Resin-Treated Wood and Laminated Hydrolyzed-Wood and Paper-Base Plastics—R. C. Weatherwax and A. J. Stamm. (*Trans. A.I.E.E. (Elec. Eng.)*, December, 1945), vol. 64, pp. 833-838; December, 1945.) A report on measurements giving experimental details. Graphs and data supplied show the variation of surface and volume resistivity with moisture content, resin content, and relative humidity for the types of wood examined.

621.318[.22+.322] 1270

Magnetic Materials—F. E. Robinson. (*Marconi Rev.*, vol. 8, pp. 125-135; October/December, 1945.) A review of recent improvements in the properties of hard and soft magnetic materials, obtained by cold working, heat treatment, and variations of composition. The materials considered are divided into three groups, those suitable for permanent magnets, for power apparatus such as low-frequency generators, motors and transformers, and for sound and radio apparatus at frequencies, up to 1 megacycle per second.

621.318.322.017.3 1271

Hysteresis and Eddy Losses in Single Crystals of an Alloy of Iron and Silicon—A. J. C. Wilson. (*Proc. Phys. Soc.*, vol. 58, pp. 21-29; January 1, 1946.) The total energy dissipated in single crystals of iron containing 2.1 per cent silicon has been measured calorimetrically, for fields in the three crystallographic directions [100], [110], and [111], the losses being analyzed by variation

with frequency. The eddy losses do not depend on field direction, but the hysteresis loss for [100] is about one-third that for the other directions. A tentative theory is put forward.

621.385.832 1272

Phosphors and Their Behavior in Television Part I—I. Krushel. (*Elec. Ind.*, vol. 4, pp. 100-134; December, 1945.) A general account of the properties of phosphors, including graphs showing spectral properties of common types, with a description of manufacturing processes.

621.385.832 1273

Phosphors and Their Behavior in Television Part II—I. Krushel. (*Elec. Ind.*, vol. 5, pp. 92-150; January, 1946.) The following production methods of coating tubes are described and their advantages discussed: spraying, dusting, settling, "flowing-on," and electrostatic deposition. Problems of "ion burn" and dissipation of screen charges are specifically treated. Contrast and brilliancy, although sufficient for direct viewing, are not at present adequate for satisfactory projection. For part I, see 1272.

621.315.6(083.75) 1274

ASTM Standards on Electrical Insulating Materials (with related information) [Book Review]—ASTM Committee D-9. American Society for Testing Materials, Philadelphia, Pa., 1945, 560 pp., \$3.25. (*Elec. Eng.*, vol. 65, pp. 97-98; February, 1946.)

621.357.7 1275

Electroplating, A Survey of Modern Practice, including the Analysis of Solutions [Book Review]—S. Field and A. D. Weill. Pitman Publishing Corp., New York, N. Y. fifth edition, 1945, 483 pp., \$5.00. (*Elec. Eng.*, vol. 64, p. 470; December, 1945.)

MATHEMATICS

517.432 1276

The Steady-State Operational Calculus—D. L. Waidelich. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 34, pp. 78P-83P; February, 1946.) "The direct and inverse transforms of the steady-state operational calculus are presented, together with two methods of evaluating the inverse transform, the first resulting in a Fourier series and the second giving a sum function. A proof of the inversion theorem connecting the two transforms is outlined in the Appendix. Two examples are presented illustrating the application of this operational calculus to circuit problems, and a comparison is made between the ordinary and the steady-state operational calculuses."

517.941.91 1277

Computation of the Solution of Mathieu's Equation—N. W. McLachlan. (*Phil. Mag.*, vol. 36, pp. 403-414; June, 1945.)

517.5(021) 1278

Lehrbuch der Funktionentheorie—Vols. I and II [Book Review]—L. Bieberbach. Chelsea Publishing Co., New York, N. Y., 1945, Vol. I (fourth edition, 1934) 320 pp., \$3.50, Vol. II (second edition, 1931) 368 pp., \$3.25. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 1, p. 104 W, February, 1946.) American reprint of the German text.

517.564.4: 518.2

1279

Tables of Associated Legendre Functions [Book Review]—Mathematical Tables Project, Columbia University Press, New York, N. Y., 1945, 303 pp., \$5.00. (*Electronics*, vol. 19, p. 344; January, 1946.) Fourteen major tables of functions and their first derivatives with five supplementary tables. To about six significant figures at intervals of 0.1.

621.396.029.6

1280

The Mathematics of Ultra-High Frequencies in Radio [Book Review]—L. N. Brillouin. Brown University, Providence, R. I., 1943, 210 pp. (*Proc. Phys. Soc.*, vol. 58, pp. 128-129; January 1, 1946.) A mimeographed record of a course of lectures at Brown University.

MEASUREMENTS AND TEST GEAR

621.3.012.3: 621.3.081.4

1281

Decibel Conversion Chart—R. C. Miedke. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 1, pp. 76W-77W; February, 1946.) The chart gives decibels directly from any two values of voltage, current, or power, for ratios up to 10 to 1, with an extended range for ratios up to 10^6 to 1.

621.317.32: 537.221

1282

A Modified Kelvin Method for Measuring Contact Potential Differences—W. E. Meyerhof and P. H. Miller, Jr. (*Rev. Sci. Instr.*, vol. 17, pp. 15-17; January, 1946.) The two surfaces are brought rapidly together and give a pulse to an electrometer tube used as a cathode follower. By adjusting the bias, this pulse is reduced to zero and measures the contact potential difference to 0.01 volt.

621.317.32.015.33: 621.385.2

1283

Pulse Response of Diode Voltmeters—A. Easton. (*Electronics*, vol. 19, pp. 146-149; January, 1946.) A theoretical and experimental investigation. Equation (11) gives the mean rectified voltage in terms of the parameters of the pulse and the voltmeter, and is closely confirmed by experiment. It is stressed that the input impedance may be relatively small for short pulses. When measuring very short pulses, the voltmeter performance can be improved by the use of a cathode follower and a pulse-stretching circuit; a practical arrangement is shown.

621.317.382.029.3

1284

Power Measurements at Audio Frequencies—D. L. Waidelich. (*Elec. Ind.*, vol. 5, pp. 68-70; February, 1946.) Describes the three-voltmeter method as given by Laws in his book "Electrical Measurements" (2508 of 1938). A second method, using a network and two thermojunction milliammeters with the output electromotive forces connected in opposition, has a linear calibration. Variable resistors are used for setting up the scale accurately. The relative advantages of the two systems are enumerated.

621.317.39

1285

Electric Measuring Instruments—D. M. Nielsen. (*Elec. Eng.*, vol. 65, pp. 66-74; February, 1946.) A survey of the instruments used for the measurement of process variables such as temperature, pressure, flow, pH, etc., in terms of electrical variables, and

of the way in which electronic devices are influencing the design of the sensitive elements, measuring mechanisms, and controlling mechanisms of the instruments. Table I lists electrically sensitive elements in terms of the physical variable measured, and Table II gives additional applications where the electrical element is combined with another responsive element. The basic features of electronic measuring instruments in general are given together with detailed descriptions of a commercial self-balancing bridge and three self-balancing potentiometers. Reasons are given for the increased use of electronic and electromechanical devices.

621.317.41+621.317.43: 621.318.323.2.029.5
1286

Proposed Test Coils—(*Elec. Ind.*, vol. 5, p. 71; January, 1946.) "Tentative standards for testing permeability and Q of powdered iron slugs $\frac{3}{8}$ inch in diameter and $\frac{3}{4}$ inch long."

621.317.42
1287

Fluxmeter—Marion Electric Instrument Co. (*Rev. Sci. Instr.*, vol. 17, p. 41; January, 1946.) A direct-reading fluxmeter with overall accuracy better than 1 per cent. A D'Arsonval movement is situated in the field to be measured and the current observed that is required to give a standard deflection. Field range 1200 to 9600 gauss.

621.317.7+621.38+621.396.69
1288

Physical Society's Exhibition: First Post-war Show of Testing and Measuring Gear—(*Wireless World*, vol. 52, pp. 48-52; February, 1946.) See also 1131/1133 of April.

621.317.7
1289

The Physical Society's Thirtieth Annual Exhibition: Electrical Instruments—G. H. Rayner. (*Jour. Sci. Instr.*, vol. 23, pp. 31-34; February, 1946.) A review of instruments including the electron microscope, voltmeters, frequency meters, alternating-current bridges, oscillators, signal generators, and a new alternating-current-direct-current comparator. See also 1131/1133 of April.

621.317.71: 621.396.67
1290

Remote Indicating Antenna Ammeter—C. R. Cox. (*Electronics*, vol. 19, pp. 210-214; January, 1946.) A diode rectifier coupled to the antenna through a current transformer, with a direct-current microammeter giving approximately linear calibration.

621.317.734
1291

A Simple Ohmmeter—"Calibrator." (*Wireless World*, vol. 52, p. 44; February, 1946.) Brief description of a circuit in which a single milliammeter is used alternately for measuring the current through and the potential drop across the unknown resistor. Resistances up to 10^6 ohms can be measured.

621.317.734
1292

Resistance Measurements—S. Litt. (*Radio News*, vol. 35, pp. 44-135; January, 1946.) Review of various methods of resistance measurement, including commercial ohmmeters with accuracy of 1 per cent for very low resistance values, and bridge-type ohmmeters of greater accuracy.

- 621.317.76: 621.396.621 1293
Laboratory Receiver—W. F. Frankart. (*Elec. Ind.*, vol. 5, pp. 71, 144; February, 1946.) Circuit details of a high-stability very-high-frequency receiver for frequency deviation and mean carrier-frequency measurements. It includes a radio-frequency stage, a frequency changer, and separate intermediate-frequency channels for amplitude and frequency modulation.
- 621.317.761+621.396.611.21.029.3 1294
Stabilizing Frequency in LF [1-10 kc/s]
Crystal Oscillators—L. R. Cox. (*Elec. Ind.*, vol. 5, pp. 106-124; February, 1946.) The amplitude-frequency effect in duplex flexure mode is reduced from 2 in 10^6 to a few parts in 10^7 by the use of a varistor in a voltage-limiting circuit. Summary of U. S. Patent 2,385,260.
- 621.317.761.029.62/.64 1295
Introduction to U. H. F. Frequency Measurements—G. Dexter. (*Radio News*, vol. 35, pp. 32-114; January, 1946.) The principles and limitations of various methods of frequency measurement above 150 megacycles per second are described, including inductance-capacitance wavemeters and Lecher-wire systems. A cavity resonator with crystal detector, and a heterodyne instrument with butterfly oscillator and crystal mixer, are described rather more fully.
- 621.317.79: 537.228.1 1296
Quartz Crystal Measurement—C. W. Harrison. (*Radio*, vol. 29, pp. 16-22; December, 1945.) Illustrated summary of 3325 of 1945.
- 621.317.79: 621.396.615.12 1297
Test Oscillator for New AM-FM-Tele Needs—W. Muller. (*Elec. Ind.*, vol. 5, pp. 86-89; February, 1946.) The necessary and desirable properties of a versatile standard-signal generator for frequency modulation and television frequencies are considered, and the design of a suitable instrument is discussed in detail. It covers the ranges 100 kilocycles per second to 150 megacycles per second, and 1 microvolt to 1 volt, with provision for frequency modulation and amplitude modulation, and incorporates crystal-controlled oscillators at 100 kilocycles per second and 1 megacycle per second. It is claimed to be "almost foolproof and obsolescence-proof."
- 621.317.79: 621.396.615.14 1298
135 to 500 Megacycle Signal Generator—J. Wonsowicz and H. S. Brier. (*Radio News*, vol. 35, pp. 35-116; January, 1946.) A design within the scope of a home workshop is described. The frequency range of nearly 4 to 1 on single band is given by a tank circuit of novel construction. An unbalanced output is obtained through a simple coaxial tapped-line attenuator. Modulation at 400 and 1000 cycles per second is provided.
- 621.317.79: 621.396.62 1299
R.F.-I.F.-A.F. Signal Tracer for Receiver Testing—V. Cavalieri. (*Radio News*, vol. 35, pp. 50-133; January, 1946.) A 3-tube audio-frequency amplifier of which the input circuit acts as grid-leak detector for modulated radio-frequency and intermediate-frequency signals. A magic-eye indicator is used for continuous-wave signals. Constructional details.
- 621.392.43 1300
Shunt and Series Sections of Transmission Line for Impedance Matching—Tai. (*See* 1178.)
- 621.315.6(083.75) 1301
ASTM Standards on Electrical Insulating Materials (with related information) [Book Review]—ASTM Committee D-9. (*See* 1274.)
- OTHER APPLICATIONS OF RADIO AND ELECTRONICS**
- 534.321.9: 620.179 1302
Supersonic Flaw Detector—(*See* 1148/1149.)
- 537.531 1303
Some Experiences with the X Ray—W. D. Coolidge. (*Elec. Eng.*, vol. 64, pp. 423-426; December, 1945.) Personal reminiscences of the author's work in the early days of X-ray development. Voltage-supply difficulties are mentioned and also modifications to tubes for practical application of X rays. The article also appears in *Amer. Jour. Roentgenol.*
- 537.531: [5+6] 1304
Scientific Importance of X-Rays—L. H. Garland. (*Elec. Eng.*, vol. 64, pp. 437-444; December, 1945.) An outline of the applications and value of X rays to industry and science in general, and particularly to medical science.
- 537.531: 62 1305
Industrial X-Ray Developments—C. D. Moriarty. (*Elec. Eng.*, vol. 64, pp. 433-435; December, 1945.) An account giving special attention to modern methods of recording results. Radiographic, fluoroscopic, and electrical methods of recording are discussed.
- 612.82.014.421: 621.395.645 1306
Brain Wave Records in Medical Diagnosis—F. Offner. (*Elec. Ind.*, vol. 5, pp. 72-161; January, 1946.) The recording of potential differences on the surface of the scalp needs amplifiers with a frequency response from a fraction of a cycle to 10 kilocycles per second, and an amplification of about 140 decibels. Four- or five-stage resistance-capacitance-coupled push-pull amplifiers with balanced input are used. A Rochelle-salt-crystal-driven recorder gives a satisfactory recording speed for use up to 100 cycles per second.
- 621.365.[5+92] 1307
Case Studies of RF Heating—Westinghouse Electric Corporation. (*Elec. Ind.*, vol. 5, pp. 84-85; January, 1946.) Eight annotated photographs showing methods of solving typical industrial problems.
- 621.365.92: 615.452 penicillin 1308
Radio-Frequency Dehydration of Penicillin Solution—G. H. Brown, R. A. Bierwirth, and C. N. Hoyler. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 1, pp. 58-65; February, 1946.) Preliminary concentration of the solution under reduced pressure is effected by using a 2-kilowatt, 28-megacycle-per-second oscillator. Further dehydration in bottles revolving at high speed reduces the moisture content to 4 per cent in 3 minutes. The equipment can produce 2000 dry bottles each hour.
- 621.383 1309
Photoelectric Aid for the Blind—(*Electronics*, vol. 19, pp. 204-210; January, 1946.) A device which is used to scan the path ahead. A beam of light is projected, and any reflection from objects is detected by a photocell which produces coded tone signals in an earphone. The range limit is 20 feet, and the coded signal heard indicates the distance of the object. The equipment weighs 9 pounds, but may be reduced to about 2 pounds.
- 621.383: 535.33.071 1310
Electronic Spectroscopy—G. C. Sziklai and A. C. Schroeder. (*Phys. Rev.*, vol. 68, p. 284; December 1-15, 1945.) The color content of light falling on a photocell may be directly observed on an oscilloscope. The method lends itself to color-matching by using two similar devices giving signals of opposite polarity and hence zero combined output when the colors match. Abstract of an American Physical Society paper.
- 621.384 1311
Production of Particle Energies Beyond 200 Mev—L. I. Schiff. (*Rev. Sci. Inst.*, vol. 17, pp. 6-14; January, 1946.) The betatron, synchrotron, microtron, linear resonator accelerator, linear wave-guide accelerator, and relativistic ion cyclotron are proposed and briefly described.
- 621.385 1312
Physical Limitations in Electron Ballistics—Pierce. (*See* 1395.)
- 621.385.833 1313
Space Charge-Limited Beams in Electrostatic Fields—M. E. Rose. (*Phys. Rev.*, vol. 68, p. 287; December 1-15, 1945.) The case dealt with is the circularly symmetric beam of finite cross section. Only first-order optics in which the aberration is due to space charge is treated. Abstract of an American Physical Society paper.
- 621.385.833 1314
On the Improvement of Resolution in Electron Diffraction Cameras—J. Hillier and R. F. Baker. (*Jour. Appl. Phys.*, vol. 17, pp. 12-22; January, 1946.)
- 621.385.833 1315
Complete Computation of Electron Optical Systems—H. Motz and L. Klanfer. (*Proc. Phys. Soc.*, vol. 58, pp. 30-41; January 1, 1946.) The field of the system is calculated by relaxation (see also 658 of March —Motz and Worthy), and the electron trajectories by step-by-step integration. "The position of focal and cardinal points and the spherical aberration of the lens are found to be in fair agreement with experimental and semi-empirical determinations by other authors."
- 621.385.833 1316
Applied Electron Microscopy—J. H. L. Watson. (*Canad. Jour. Res.*, vol. 21, Sec. A, pp. 89-98; November, 1943.) The technique of taking stereoscopic photographs, and its adaptation to give electron diffraction patterns, is described in relation to the examination of mine dust, clays, and the structure of botanical specimens.
- 621.385.833 1317
Electron Microscope Society of America

—(*Jour. Appl. Phys.*, vol. 17, pp. 66-68; January, 1946.) Abstracts of 25 papers from the Society's program.

621.385.833 1318
Applications of Metallic Shadow-Casting to Microscopy—R. C. Williams and R. W. G. Wyckoff. (*Jour. Appl. Phys.*, vol. 17, pp. 23-33; January, 1946.)

621.385.833 1319
A High Speed Microtome for the Electron Microscope—E. F. Fullam and A. E. Gessler. (*Rev. Sci. Instr.*, vol. 17, pp. 23-35; January, 1946.)

621.389: 778.52 1320
Electronic Timing of Sequence Photographs—C. H. Coles. (*Elec. Ind.*, vol. 5, pp. 74-76; February, 1946.) Circuit details and photographs of apparatus for photographing bullets in flight. A rising voltage is applied to a number of tubes biased to different amounts beyond cutoff. As each tube conducts, it applies a pulse to a stroboscopic lamp. Six lamps may be fired in succession in a time between 35 microseconds and $\frac{1}{2}$ second.

621.398: 621.318.5 1321
Industrial Relay Control Circuits—R. R. Batcher. (*Elec. Ind.*, vol. 5, pp. 94-134; February, 1946.) Methods of remote control are outlined. The operation of simple relays is described, and it is shown how complex problems are solved by combinations of relays. Selective control is effected by pulse-operated switching circuits of the types used in telephone exchanges.

621.398: 623 1322
Radio Control of German V-2 Rockets—(*Elec. Ind.*, vol. 4, p. 89; December, 1945.) Brief note only. See also 4135 of 1945.

621.398: 629.13 1323
Radio Operated Airplane—S. R. Winters. (*Radio News*, vol. 35, pp. 29-159; January, 1946.) Four audio-frequency tones on an ultra-high-frequency carrier control a small plane. Switching off a fifth tone stops the engine and releases a parachute. See also 1324 below.

621.398: 629.13 1324
Radio-Controlled Target Airplane Developed by ATSC—(*Radio News*, vol. 35, p. 66; January, 1946.) See also 1323 above and 1013 of April.

623.26: 621.396.9 1325
Vehicular-Mounted Mine Detector—H. G. Doll, M. Lebourg, and G. K. Miller. (*Electronics*, vol. 19, pp. 105-109; January, 1946.) A device that automatically stops the vehicle on detection of a metal mine or on failure of the electronic apparatus. Four circular horizontal coils side by side and in series are transmitters (presumably alternating frequency). Four receiving coils are fixed on top of the transmitters, and the mutual inductance between transmitting and receiving circuits is neutralized by a group of transformers in opposite polarity in series with the coils. The coil assembly forms the detector element, and is electrostatically screened. Residual signal in the receiving circuit is neutralized by the injection of a signal automatically controlled by a long-time-constant circuit to counteract drift from balance. Passage of the detector over

a mine causes a sudden change in mutual impedance between the coils, too quick for automatic compensation, and the resulting signal in the receiver operates braking relays. The arrangement is particularly sensitive to change in the resistive component of the mutual impedance, which is of advantage in discriminating against false signals. The complete circuit diagram is given with component values.

623.454.25: 621.396.9 1326
Radio Proximity Fuze—H. Trotter, Jr. (*Electronics*, vol. 19, pp. 226-228; January, 1946.) Summary of an Institute of Radio Engineers paper describing the history of the subject.

016: 621.386.1: 620.179 "1942/1945" 1327
Bibliography on Industrial Radiology [Book Review]—H. R. Isenburger. St. John X-Ray Service, Inc., Long Island City, N. Y., 16 pp., \$1.00. (*Electronics*, vol. 19, p. 344; January, 1946.) Mimeographed list of about 400 items published between 1942 and 1945. Supplement to 723 of 1944.

621.38: 62 1328
Elementary Engineering Electronics [Book Review]—A. W. Kramer. Instruments Publishing Co., Pittsburgh, Pa., 1945, 344 pp., \$2.00. (*Elec. Ind.*, vol. 5, p. 128; January, 1946.)

PROPAGATION OF WAVES

534+538.56 1329
The Wave Equation in a Medium with a [space] Variable Index of Refraction—P. G. Bergmann. (*Phys. Rev.*, vol. 68, p. 286; December 1-15, 1945.) Abstract of an American Physical Society paper.

621.396.11 1330
Polarized Radiation—J. Grosskopf and K. Vogt. (*Elec. Ind.*, vol. 4, p. 113; December, 1945.) Summary of 2842 of 1944, with two graphs.

621.396.11 1331
Propagation Effects—(*Elec. Ind.*, vol. 5, pp. 65-142; February, 1946.) A brief report of a conference held at the Cosmic Terrestrial Research Laboratory, Needham, Mass., on December 11, 1945, on ionospheric and tropospheric propagation. Ionospheric and path absorption, sporadic "E," and scatter were discussed. Extended fadeouts were reported on 110 megacycles per second over a distance of 70 miles which were greatly reduced by operation in the 40- to 50-megacycle-per-second band. See also 1334.

621.396.11: 523.746.5: 551.15.053.5 1332
The New Sunspot Cycle—Bennington. (See 1235.)

621.396.11: 621.396.812.3 1333
Irregularities in Radio Transmission: Part 1—O. P. Ferrell. (*Radio*, vol. 29, pp. 27-61; December, 1945.) A review of evidence that "bursts" are due to low-level ionospheric reflections. A graph representing measurements made over 337- and 720-mile paths at a frequency of 42.3 megacycles per second shows the average number of bursts per hour against field intensity of the received signal. The curve falls from 80 bursts per hour exceeding 6 microvolts per meter to 2 bursts per hour exceeding 26

microvolts per meter. Twenty references are given.

621.396.11.029.62 1334
Tropospheric Study of FM Transmission—C. W. Carnahan. (*Elec. Ind.*, vol. 4, pp. 78-146; December, 1945.) A long account of the Institute of Radio Engineers paper by Carnahan. See also 1028 of April, and 1335 below.

621.396.11.029.62 1335
FM Tests—F. C. C. (*Elec. Ind.*, vol. 4, pp. 80-81; December, 1945.) Report of controversy over the significance of results given in 1028 of April and in 1334 above (Carnahan). Federal Communications Commission tests at 20 miles range are stated to indicate the reverse of the conclusions drawn from Carnahan's measurements.

621.396.11.029.64+538.569.4 1336
The Absorption of Microwaves by Gases—W. D. Hershberger. (*Phys. Rev.*, vol. 68, p. 284; December 1-15, 1945.) Fourteen gases give absorptions at about 1 centimeter wavelength comparable with that of ammonia. The frequency at which the absorption coefficient is maximum is obtained from graphs of the coefficient against pressure. Abstract of an American Physical Society paper.

621.396.615.17 1337
A New Pulse Generator Circuit [useful for ionospheric sounding]—Banerjee. (See 1210.)

RECEPTION

621.394./397.813 1338
Defining Distortion—M. G. Scroggie. (*Wireless World*, vol. 52, pp. 99-100; March, 1946.) A letter criticizing the following definitions in the British Standard Glossary of Terms used in Telecommunication: 1301 Distortion; 1302 Attenuation Distortion; 1304 Delay Distortion; 1305 Nonlinear Distortion, 1307 Harmonic Distortion; 1308 Intermodulation Distortion.

621.396.61/.62+621.395.645 1339
Low Power Transmitting, Receiving, and Hailing Equipment. Type CNY. 1—Morcom. (See 1386.)

621.396.62: 621.396.662 1340
A Simple Remote Tuning Device for Receivers—E. L. Hannum, Jr. (*Radio News*, vol. 35, pp. 76, 82; January, 1946.) Bandspread about a selected communication frequency is achieved by varying the grid bias of a reactor vacuum tube connected across the tuned circuit of the receiver local oscillator, using a direct-current line circuit with remote potential-divider control. The control line is also used to carry the receiver audio-frequency output to the control point. The system is useful when it is necessary to locate a receiver perhaps several miles from the control center in order to avoid noise interference with reception.

621.396.621: 621.317.76 1341
Laboratory Receiver—Frankart. (See 1293.)

621.396.621.54 1342
Practical Radio Course: Part 40—A. A. Ghirardi. (*Radio News*, vol. 35, pp. 57-151; January, 1946.) "The effects [and causes

of resonant-frequency 'drifts' in the pre-selector, intermediate-frequency amplifier, and oscillator-tuning circuits of a superheterodyne-type receiver."

621.396.621.54 1343

Amateur Communication Receiver—H. B. Dent. (*Wireless World*, vol. 52, pp. 36-40; February, 1946.) The basis of the design of a short-wave superheterodyne receiver with two frequency conversions. The conversion is first to 1.8 megacycles per second and second to 100 kilocycles per second, giving good second-channel and adjacent-channel selectivity. The circuit diagram is given.

621.396.621.59 1344

Discriminating between Signals of Different Amplitude—E. H. Ullrich. (*Elec. Ind.*, vol. 4, pp. 120, 170; December, 1945.) "A method which permits the separation of pulse-modulated waves where the frequency and the energy at the receiver may be identical, but the amplitude and/or duration are different." Summary of U. S. Patent 2,381,847.

621.396.621.59 1345

Exalted-Carrier Amplitude- and Phase-Modulation Reception—M. G. Crosby. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 34, p. 90P, February, 1946.) Discussions of 3516 of 1945.

621.397.8 1346

Television for Urbanized Areas [siting of aerials]—Duvall. (*See* 1384.)

STATIONS AND COMMUNICATIONS SYSTEMS

621.396.619 1347

Phase and Frequency Modulation—E. Green (*Marconi Rev.*, vol. 8, pp. 113-118; October/December, 1945.) Vector diagrams are used to show the relationship between phase and frequency modulation, and to derive the relative gain in signal-to-noise ratio of these types of modulation over amplitude modulation for various values of modulation index.

621.396.619: 621.385.5 1348

Phasitron Converts from AM to FM Directly—(See 1405.)

621.396.619.018.41 1349

Frequency Modulator—D. A. Bell. (*Elec. Ind.*, vol. 5, pp. 118, 120; January, 1946.) When two signals at different frequencies are applied to a limiter, one component of the output has a frequency intermediate between the input frequencies, dependent on the relative amplitude of the inputs. Thus if one input is amplitude-modulated, this output component is correspondingly frequency-modulated. Summary of U. S. Patent 2,384,789.

621.396.619.16 1350

Pulse Position Modulation Technic—(Elec. Ind., vol. 4, pp. 82-190; December, 1945.) A detailed general technical account of the Bell system described in 740 of March, including block diagrams and some circuit diagrams of the equipment.

621.396.619.16 1351

Pulse Modulation—F. F. Roberts and J. C. Simmonds. (*Wireless Eng.*, vol. 23, p. 93; March, 1946.) Suggested definitions and

abbreviations for terms used in the various forms of pulse modulation. Sharp leading and trailing edges are assumed. See also 1053 of April (Cooke) and 183 of January (Roberts and Simmonds).

621.396.619.16 1352

Pulse-Time Modulation: An Explanation of the Principle—(Wireless World, vol. 52, pp. 45-46; February, 1946.)

621.396.65.029.62/64 1353

The [U.S.] Army's Radio Relay Equipment—A. R. Boone. (*Radio News*, vol. 35, pp. 25-155; January, 1946.) The AN/TRC-1 is a frequency-modulation set transmitting at 70 to 100 megacycles per second from a double-H aerial, providing four telephone channels. The AN/TRC-8 is similar but operates at 230 to 250 megacycles per second, using a dipole with a V reflector. The AN/TRC-6 (4300 to 4900 megacycles per second) uses eight interlaced pulse-position-modulated channels. The aerial is a parabolic reflector with waveguide feed. The AN/ATRC-5 is similar, but uses a dipole with paraboloid reflector (1350-1450 megacycles per second). Advantages over wire circuits include reduction in installation time, and in the number of repeater stations needed. For descriptions of AN/TRC-5 and AN/TRC-6, see 1055/1056 of April and back references.

621.396.7 1354

The [U.S.] Signal Corps on and in the Air—C. E. Jackson. (*Radio News*, vol. 35, pp. 94-98; January, 1946.) A complete airborne radio station to meet the speed, mobility, and power required in Pacific operations was prepared, using three cargo planes. The 3-kilowatt transmitter and 15-kilowatt diesel generator were carried in separate planes, parked nose to nose, with a 38-foot horizontal aerial using the aircraft as counterpoise. The receiver plane, some half-mile away, was linked by land line. A two-tone teletype system was used.

621.396.712 1355

FM in Canada—D. Holloway. (*Radio News*, vol. 35, pp. 30-140; January, 1946.) An account of controversial problems of broadcast policy.

621.396.82: 621.396.9 1356

Radar Countermeasures—D.G.F. (*Electronics*, vol. 19, pp. 92-97; January, 1946.) Description of methods of searching for, locating, and jamming enemy radars. Wide-range automatically tuned receivers with tape recording and an oscilloscopic analyzer are used for searching. Jamming is provided by tunable high-power transmitters having random-noise modulation, or by reflecting foil strips of suitable length ("window" or "chaff"). Wide-band aerial systems and the resnatron (a tetrode giving 30 kilowatts continuous wave at 500 megacycles per second) are briefly described. The more commonly used equipment is described in tabular form. See also 1059/1061 of April.

621.396.931.029.62 1357

Multi-Carrier Communication System: Diversity Transmission for Mobile Working—(Wireless World, vol. 52, pp. 59-61; February, 1946.) General description of a system used by the London police and fire services. Reliable two-way telephone com-

munication with mobile units can be maintained over a service range of 20 miles using amplitude modulation, and frequencies near 100 megacycles per second, with a 400- to 500-foot mast at the control center. The service area is extended by using additional fixed stations, supplied with synchronized and correctly phased modulation, operating at frequencies sufficiently close to one another to be within the bandwidth of the receivers, but sufficiently far apart to avoid audible beats. Signals from the mobile transmitters can be received at any of the fixed stations and relayed to the control center. The system is described in detail in an Institution of Electrical Engineers paper by J. R. Brinkley, not yet printed.

621.396.931.029.63 1358

2660-Mc Train Communication System—E. A. Dahl. (*Electronics*, vol. 19, pp. 118-122; January, 1946.) A description of a two-way frequency-modulation system, for communication between front and rear of train, and from train to wayside stations. The equipment consists of two compact units, transceiver, and power supplies. The 10-watt transmitter uses a crystal-controlled oscillator, its frequency multiplied up to 2660 megacycles per second in five stages, the last by a klystron. The signal is then klystron-amplified and fed to the aerial. For reception, the same frequency-multiplying chain is used with a crystal of slightly different frequency to serve as local oscillator, which, mixed with the incoming signal, gives an intermediate frequency of 7 megacycles per second. The omniazimuthal antenna consists of six vertically stacked units, each having three curved dipoles, arranged in a circle at the focus of a biconical parabolic reflector.

621.396.97: 356.251.11 1359

Listening to the World—C. Cross. (*Radio News*, vol. 35, pp. 64-141; January, 1946.) A nontechnical review of the British Broadcasting Corporation's wartime monitoring service. See also 197 of January.

621.396: 629.13 1360

Aviation Radio [Book Review]—Roberts. (*See* 1256.)

SUBSIDIARY APPARATUS

539.16.08 1361

Experiments with Triode [particle-] Counters—S. A. Korff. (*Phys. Rev.*, vol. 68, p. 284; December 1-15, 1945.) Abstract of an American Physical Society paper.

621-526 1362

Electrical Analogy Methods Applied to Servomechanism Problems—G. D. McCann, S. W. Herwald, and H. S. Kirschbaum. (*Trans. A.I.E.E. (Elec. Eng.*, February, 1946), vol. 65, pp. 91-96; February, 1946.) The treatment of angular-position mechanisms and a description of the transient analyzer are given, with typical transient-response curves. Effects of varying controlling parameters are shown.

621.314.634: 621.396 1363

Dry-Contact Rectifiers for Radio Applications—G. Herbert. (*Radio*, vol. 29, pp. 29-61; December, 1945.) Details of construction and performance of selenium rectifiers, including efficiency, regulation, and current

characteristics. A chart shows sizes and current capacity of rectifier plates.

621.314.67

Capacitor-Charging Rectifier—H. J. Bichsel. (*Electronics*, vol. 19, pp. 123-125; January, 1946.) Experimental determination of design criterion for a reactance-limited rectifier required to charge a large capacitor bank in the shortest time and with the least power demand on the mains. The capacitor normally charges rapidly until the charging pulses become discrete, and then the charge rate falls. This point, when $E \approx 0.6E_{\max}$ is the most economical point at which to discharge.

621.316.722.1.078.3

Electronic A-C Voltage Regulator—L. D. Harris. (*Electronics*, vol. 19, pp. 150-151; January, 1946.) The direct-current output from a rectifier is compared with the potential drop across a stabilizing tube. The difference is used to alter the direct-current load on another rectifier system with its transformer primary in series with the mains. The change of reactance of this winding reduces the fluctuations at the mains output terminals to about 6 per cent of their original value. Third-harmonic content of the supply is also reduced.

621.316.722.1.078.3.

Stabilized D-C High-Voltage Supply—A. M. Gurewitsch and P. C. Noble. (*Gen. Elec. Rev.*, vol. 48, pp. 46-52; December, 1945.) The supply was designed for an electron-diffraction instrument. A 35-kilocycles-per-second power-oscillator output is amplified, transformed to 15 kilovolts, and rectified by means of a voltage-quadrupling circuit to give 60 kilovolts with an output of 60 watts. The filaments of the rectifiers and also the filament of the electron gun are each supplied from separate 250-kilocycles-per-second power oscillators. Automatic regulation is obtained by applying some of the output voltage to the screen of the driving oscillator. A 10 per cent change in input voltage, or a load varying from 0.5 to 1.0 milliampere, causes the output voltage to vary less than 0.1 per cent. The alternating-current ripple is about 0.05 per cent.

621.316.722.1.078.3

A Voltage Regulator for X-Ray Circuits—W. P. Davey. (*Phys. Rev.*, vol. 68, p. 285; December 1-15, 1945.) Changes in the rectified mains voltage operate a relay train to a motor which moves the field rheostat of a 20-kilovolt-ampere alternator in the appropriate direction. The alternating voltage is regulated to ± 0.02 volt in 110 volts. Abstract of an American Physical Society paper.

621.317.083.7+621.398

New Power Operated Sensitive [meter] Recorder—P. G. Weiller. (*Elec. Ind.*, vol. 5, pp. 88-140; January, 1946.) Contact of the meter pointer with one of two graphite blocks starts a motor, through a triode and relay, which moves the block away from the pointer, and simultaneously operates a means of remote indication or control. Precautions taken avoid hunting, sticking of contacts, or interruption of operation by electrostatic forces or absorbed gases on the contacts. Any meter with a torque of 0.02

gram-centimeter or more for full-scale deflexion may be used.

621.318.42.029.6

R. F. Chokes at u.h.f.—W. J. Stolze. (*Radio News*, vol. 35, pp. 54-114; January, 1946.) Chokes should have very high impedance at the working frequency, sufficiently low resistance, and the wire should have sufficient current-carrying capacity. Choke connections should be as short as possible. A design chart gives recommended numbers of turns for frequencies from 40 to 160 megacycles per second. Examples of uses for chokes are given, and the use of transmission lines as chokes is mentioned.

621.384.6

100 Million Volt Electron Accelerator—(*Elec. Ind.*, vol. 4, pp. 90-168; December, 1945.) An account of the device described in 438 of February (Westendorp and Charlton).

621.386(091)

X-Ray History and Development—W. D. Coolidge and E. E. Charlton. (*Elec. Eng.*, vol. 64, pp. 427-432; December, 1945.) See 770 of March. This paper also appears in *Radiology*, December, 1945.

621.386(4)

50 Years of X-Ray Progress in Europe—J. H. van der Tuuk. (*Elec. Eng.*, vol. 64, pp. 444-448; December, 1945.)

621.398: 621.318.5

Industrial Relay Control Circuits—Batcher. (See 1391.)

621.398: 621.396.662.

Automatic Positioning Control Mechanisms—R. W. May and N. H. Hale. (*Elec. Ind.*, vol. 5, pp. 58-158; January, 1946.) A review of types of mechanisms suitable for rapid readjustment of the controls of multifrequency transmitters. The Collins Autotune is described in detail.

621-526

Fundamental Theory of Servomechanisms [Book Review]—L. A. MacColl. D. Van Nostrand Company, Inc., New York, N. Y., \$2.50. (*Elec. Ind.*, vol. 5, p. 163; February, 1946.) "It is scholarly and will well repay the expert or would-be expert for its study."

TELEVISION AND PHOTOTELEGRAPHY

621.383.8

High Sensitivity Pickup—(*Elec. Ind.*, vol. 4, pp. 88-89; December, 1945.) A short account of the RCA image orthicon, a television camera tube about 100 times more sensitive than previous instruments. Electrons are emitted from a photoelectric screen, and are attracted electrostatically to a nonconducting target, where they cause the emission of secondary electrons, leaving a pattern of positive charges corresponding to the original light image. The back of the target is scanned by an electron beam that has just enough energy almost to reach the screen before being turned back to the gun by the electrostatic forces. When the beam scans a part of the target that is positively charged, sufficient electrons are attracted from the beam to neutralize the charge, leaving the returning beam correspondingly

deficient. The returning beam is, therefore, modulated according to the electrical pattern on the target. It strikes the front of the electron gun, causing the emission of secondary electrons that are attracted by the plates of an electron multiplier from which the output is obtained. For another account, see *Electronics*, vol. 18, p. 330; December, 1945.

621.385.832

Phosphors and Their Behavior in Television [Parts I and II]—Krushel. (See 1272/1273.)

621.397

[U.S.] Industry Standardization Work in Television—D. B. Smith. (*Elec. Ind.*, vol. 4, pp. 192, 194; December, 1945.) A brief survey of proposals for further standardization of the television service on the lower frequency range of operation. Reference is made to three-dimensional color television. Summary of an Institute of Radio Engineers paper. See also *Electronics*, vol. 19, pp. 244-246; January, 1946.

621.397: 535.317

[Optical] Lens Aberrations in Picture Projection—A. Montani. (*Elec. Ind.*, vol. 5, pp. 86, 87, 150; January, 1946.) Qualitative description of six types of aberration which should be corrected in television equipment.

621.397: 621.396.619.1

Amplitude Modulator for Facsimile—Artzt. (See 1390.)

621.397.3: 621.396.615.17

Television Sweep Oscillators—E. M. Noll. (*Radio News*, vol. 35, pp. 52-74; January, 1946.) The basic theory of sawtooth voltage generators, including the multivibrator, blocking oscillator, and gas-discharge oscillator. Part II of a series beginning with 782 of March.

621.397.5: 621.396.619.16

Transmission of Television Sound on the Picture Carrier—G. L. Fredendall, K. Schlesinger, and A. C. Schroeder. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 34, pp. 49P-61P; February, 1946.) A discussion of duplex transmission using several types of pulse modulation. "The advantages of duplex transmission are: (1) elimination of a separate sound transmitter; (2) elimination of the ambiguity and difficulty which may occur when a standard frequency-modulated sound signal is tuned in; (3) freedom of the audio output from the type of distortion which occurs in frequency-modulated receivers as a consequence of excessive drift of the frequency of the local oscillator; and (4) improvement of the phase characteristic of the picture intermediate-frequency amplifier resulting from elimination of trap circuits."

"With the exception of pulsed frequency modulation, the signal-to-noise ratios of sound in duplex systems are not so great as the ratio offered by the transmission of a standard frequency-modulated carrier. The comparison is subject to the condition that the amplitude of the frequency-modulated carrier is 0.7 of the peak amplitude of the duplex carrier. The signal-to-noise ratio of a pulsed frequency-modulated signal may equal the ratio of a standard frequency-modulated signal up to a critical distance

from the transmitter, but is less at greater distance."

621.397.62 1383

Television Psychology: Is the Large Screen Essential?—B. Bellac. (*Wireless World*, vol. 52, p. 40; February, 1946.) A small, close object may subtend the same angle at the eye as a large object seen from a distance, but the convergence of the eye axes in viewing the close object gives an impression of nearness and therefore of smallness. An unpleasant impression is produced by the discrepancy between the smallness of the image and the intensity of the sound. These faults can be overcome only by a television receiver with a projection system giving an image size comparable with that of home moving pictures.

621.397.8 1384

Television for Urbanized Areas—G. Duvall. (*Radio News*, vol. 35, pp. 88-92; January, 1946.) There is no ready-made solution for the best siting of television aerials, when line-of-sight reception is impossible. Due to reflections from physical barriers, the proper orientation of the dipoles is a matter of experiment. Maximum height consistent with feeder cable cost is an over-all aim.

TRANSMISSION

621.385.3.029.63: 621.396.615.16.029.63

1385

A Vacuum-Contained Push-Pull Triode Transmitter [Type VT158]—Zahl, Gorham, and Rouse. (*See* 1403.)

621.396.61/.62+621.395.645 1386

Low Power Transmitting, Receiving, and Hailing Equipment. Type CNY.1—W. J. Morcom. (*Marconi Rev.*, vol. 8, pp. 119-124; October/December, 1945.) This transportable equipment has facilities for telephony and telegraphy transmission, reception, and hailing. The transmitter power is 5 to 8 watts on 1.5 to 9 megacycles per second. The receiver gives an output of 3.5 watts, and the audio-frequency power input to the hailing loudspeaker is 10 watts.

621.396.61: 621.396.619.018.41 1387

Concentric Line [88-108 Mc/s band] FM Transmitter for 250 W—(*Elec. Ind.*, vol. 5, pp. 78-146; February, 1946.) Description of the Transmitter Equipment Manufacturing company equipment. Use of miniature tubes and push-pull circuits reduces problems of frequency multiplication, stability, and modulation. Electro-mechanical tuning maintains the frequency relative to a crystal-controlled oscillator.

621.396.61.029[.58+.62 1388

Unusual Transmitter for 28-54 Mc/s—R. P. Turner. (*Radio News*, vol. 35, pp. 40-126; January, 1946.) Constructional details of a 30-watt transmitter, continuously tunable throughout the frequency band, with provisions for crystal control. The controlled oscillator works on the fundamental or second harmonic of a crystal with frequency about 7 megacycles per second. The frequency is quadrupled in the driver stage. Use of a dual beam tetrode, type 815, link-coupled to the driver stage, avoids the necessity for neutralization.

621.396.615.12

Transitron Oscillator for High Stability—W. Muller. (*Elec. Ind.*, vol. 4, pp. 110-138; December, 1945.) An oscillator to cover the range 40 to 175 kilocycles per second with a stability of ± 4 cycles per second between -40 and 60 degrees centigrade, and for line-voltage variations of ± 25 per cent was required. Of three types considered (including phase-shift and electron-coupled oscillators), the transitron oscillator best fulfilled the requirements. A detailed description is given of the design of the circuit and of the experiments on which it was based.

621.396.619.1: 621.397 1390

Amplitude Modulator for Facsimile—M. Artzt. (*Elec. Ind.*, vol. 4, p. 172; December, 1945.) A method of modulating a wave from a resistance-capacitance-coupled oscillator at the maximum possible keying rate, with freedom from transients. Summary of U.S. Patent 2,373,737.

VACUUM TUBES AND THERMIONICS

537.525

Small Perturbations of the Electric Discharge—Granovsky. (*See* 1224.)

537.533.8

Erratum: Secondary Emission of Pyrex Glass—C. W. Mueller. (*Jour. Appl. Phys.*, vol. 17, p. 62; January, 1946.) Correction to the composition of the glass quoted in 3648 of 1945 (Mueller).

621.38(083.72)

The Tron Family—W. C. White. (*Elec. Ind.*, vol. 5, pp. 80-136; January, 1946.) A glossary of names of vacuum tubes and other electronic devices having the suffix "tron," with bibliographic references to early use of the words.

621.385+621.396.615+538.561 1394

Interchange of Energy between an Electron Beam and an Oscillating Electric Field—J. Marcum. (*Jour. Appl. Phys.*, vol. 17, pp. 4-11; January, 1946.) "Relations between various parameters are obtained which describe the behavior of an accelerated electron beam which is caused to traverse an alternating electric field. In particular, a mechanico-graphical means for obtaining the gain or loss of energy is described. It is shown that under the most favorable conditions a maximum of 17 per cent of the energy in the accelerated beam may be transferred to the alternating field. Application of these principles to a type of ultra-high-frequency oscillator is treated."

621.385 1395

Physical Limitations in Electron Ballistics—J. R. Pierce. (*Bell. Sys. Tech. Jour.*, vol. 24, pp. 305-321; July-October, 1945.) Mainly a consideration of devices with large beam currents, dealing with the following points: electron lens aperture; distribution of initial velocities of electrons; space-charge effects; power-dissipation limits; effect of scaling down electron devices.

621.385 1396

Electron Ballistics in High-Frequency Fields—A. L. Samuel. (*Bell. Sys. Tech. Jour.*, vol. 24, pp. 322-352; July/October, 1945.) The five fundamental functions of an

electronic device are production of an electron beam, modulation of the beam, conversion of this modulation into a usable form, abstraction of energy from the beam, and collection of spent electrons. Conversion mechanisms in which electrons are sorted according to velocities and the "bunching" of electrons as used in magnetrons, Barkhausen tubes, diode oscillators, and klystrons are considered. The mathematical analysis of electron motions in the klystron is outlined, and diagrams given which illustrate graphically the bunching effect. The influence of space charge in modifying the bunching effect and electron paths within the magnetron is briefly discussed.

621.385

Factors Determining Industrial Tube Life—J. F. Dreyer, Jr. (*Elec. Ind.*, vol. 4, pp. 94-156; December, 1945.) Apart from mechanical defects and careless handling, the normal life of a tube depends solely on the rate of cathode emission. A curve showing the relationship between emission and expected life is given, followed by a detailed discussion on methods of obtaining optimum efficiency at minimum cost.

621.385: 623.454.25

Proximity Fuze Tubes—M. A. Acheson. (*Electronics*, vol. 19, pp. 228-236; January, 1946.) Summary of an Institute of Radio Engineers paper describing the special requirements and the expedients by which they were met.

621.385.029.64(43)

Germany's UHF Tubes—Combined Intelligence Objectives Subcommittee. (*Elec. Ind.*, vol. 5, pp. 81-122; February, 1946.) Describes construction and design principles of velocity-modulated and magnetron tubes for continuous-wave and pulse operation on bands between 10 centimeters and 3.7 millimeters wavelength. Exploration of intense electron beams is made with pieces of carbonized paper which glow when inserted in the beam. Information taken from Combined Intelligence Objectives Subcommittee reports, index numbers 58, 59, 69, 78, and 95.

621.385.1

Reflex Oscillators Utilizing Secondary Emission Current—C. C. Wang. (*Phys. Rev.*, vol. 68, p. 284; December 1-15, 1945.) To increase the power output of velocity-modulated tubes, a secondary-emission electrode is introduced to increase the beam current delivered to the gap where high-frequency energy is absorbed from the beam. The tubes have been successfully operated at 4000 megacycles per second. Abstract of an American Physical Society paper.

621.385.16.029.63/.64

Cavity Magnetrons—D.G.F. (*Electronics*, vol. 19, pp. 126-131; January, 1946.) Details of the development and construction of centimetric-wave tubes used for radar. A list of types developed for pulsed operation in the L band (25 to 50 centimeters), S band (8 to 11 centimeters), and X band (3 centimeters) is given, with the power and duty-cycle ratings. Efficiency, undesired modes, magnet construction, and output matching are discussed. The Rieke

diagram showing the effect of load impedance on output power and frequency of a typical magnetron is given. Peak powers up to and beyond a megawatt have been obtained.

621.385.16.029.63/.64 1402

Theory of Magnetron Tubes and Their Uses—H. G. Shea. (*Elec. Ind.*, vol. 5, pp. 66-70; January, 1946.) A simple derivation of cavity magnetron theory, with discussion of the results and of application to the construction of standard types. Particular reference is made to mode stability and to the "strapping" of alternate barriers. Frequency/power (Rieke) diagrams, and typical operating conditions are given for the 4J36-4J41 type.

621.385.3.029.63: 621.396.615.16.029.63 1403

A Vacuum-Contained Push-Pull Triode Transmitter [Type VT158]—H. A. Zahl, J. E. Gorham, and G. F. Rouse. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 1, pp. 66W-69W; February, 1946.) The resonating grid and plate circuits are contained in the vacuum and form integral parts of the grid and plate structures. The tube is used with a tuned filament line. It can oscillate in a narrow frequency band between 200 and 700 megacycles per second. It will give 200 to 300 kilowatts pulsed peak powers, and can also be used for continuous wave.

621.385.5: 539.16.08 1404

Use of 6AK5 and 954 Tubes in Ionization Chamber Pulse Amplifiers—V. L. Parsegian. (*Rev. Sci. Inst.*, vol. 17, pp. 39-40; January, 1946.) Results based on tests to obtain high signal-to-noise ratio with floating grid and with very high grid-leak operation.

621.385.5: 621.396.619 1405

Phasitron Converts from AM to FM Directly—(*Elec. Ind.*, vol. 5, pp. 78-79; January, 1946.) A horizontal circular disk of electrons from the cathode of the phasitron is modulated at the crystal-controlled carrier frequency by a grid system that bends the electron trajectories in a vertical direction so that the edge of the electron sheet follows a line that is sinusoidal in the vertical direction. The grid system is composed of a number of similar elements equally spaced around the vertical axis so that there are several wavelengths of vertical modulation around the complete electron sheet. Also, each grid element is threefold and fed with a three-phase voltage so that the modulation profile of the sheet rotates about the vertical axis. There is a coaxial cylindrical screen around the sheet, with holes punched in it at equiangular intervals, through which, on account of the rotation of the fluted electron sheet, are projected streams of electrons that vary in intensity at the carrier frequency. A coil of wire coaxial with the electron sheet carries audio-frequency current and produces an alternating magnetic field that deflects the electron trajectories in a circumferential direction, and consequently phase-modulates the streams of electrons passing through the holes in the screen. An anode outside the screen collects the projected electrons and therefore carries a current alternating at

the carrier frequency and phase-modulated at the audio frequency.

621.385.5: 621.396.621.54 1406

Recent Developments in Converter Tubes—W. A. Harris and R. F. Dunn. (*Electronics*, vol. 19, pp. 240-242; January, 1946.) Description of the 6SB7Y converter which has a conversion transconductance of 0.95 millampere per volt, and an oscillator transconductance of 8 milliamperes per volt. It is said to give improved gain and signal-to-noise ratio in the medium- and short-wave bands. Some details of operation around 100 megacycles per second are given. Summary of an Institute of Radio Engineers paper. See also *Elec. Ind.*, vol. 4, p. 81; December, 1945.

621.385.831: 621.396.619.018.41 1407

Ratio-Controlled Amplifier—C. W. Hansell. (*Elec. Ind.*, vol. 4, p. 120; December, 1945.) An amplifier tube intended for use with a balanced discriminator, avoiding the necessity of a limiter in frequency- or phase-modulation detector circuits. Summary of U.S. Patent 2,383,855.

MISCELLANEOUS

001.8: 62 1408

A Plea for the Scientific Method—L. Hoffer. (*PROC. I.R.E. AND WAVES AND ELECTRONS*, vol. 1, pp. 56W-57W; February, 1946.) The importance of critical discrimination, proper classification of data, scientific technique, and pure research in engineering are outlined.

001.89 1409

Science and the Government—H. M. Kilgore. (*Science*, vol. 102, pp. 630-638; December 21, 1945.) Discussion of a proposal to set up a National Scientific Research Foundation in the United States of America, in the form of a government agency, dealing with research into all problems related to national welfare.

001.891: 6(410) 1410

Alliance of Industry and Scientific Research in Great Britain—B. J. A. Bard. (*Science*, vol. 103, pp. 6-8; January 4, 1946.) Present plans for closer liaison include endowments and scholarships to be offered to the universities by industry, interchange of staff, and joint research councils.

519.283. 1411

Statistical Methods in Quality Control—VII—A.I.E.E. Subcommittee on Educational Activities. (*Elec. Eng.*, vol. 64, pp. 448-450; December, 1945.) The use of control charts and the analysis of samples in a manufacturing process to determine factors which might need correction. For previous parts, see 805 of March. See also 1412 below.

519.283. 1412

Statistical Methods in Quality Control—IX—A.I.E.E. Subcommittee on Educational Activities. (*Elec. Eng.*, vol. 65, pp. 81-83; February, 1946.) Discussion of acceptance sampling based on the method of attributes, including single sampling, double sampling, and multiple sampling. The "operating characteristics" are plotted to compare the various methods. See also 1411 above.

62

Progress Depends on Sound Engineering—J. A. Stobbe. (*Elec. Ind.*, vol. 5, pp. 72-73; February, 1946.) Emphasizes the need for close contact between engineer and consumer, and for designing for reduction of production costs.

621.3.012.3: 621.3.081.4 1414

Decibel Conversion Chart—Miedke. (*See 1281.*)

621.3.085.6+321.3.017.72 1415

Heat Dissipation from Cabinets for Electrical Instruments—H. C. Littlejohn. (*Gen. Rad. Exp.*, vol. 20, pp. 4-5; January, 1946.) A table is given showing the relative heat-dissipation properties of various materials. The most efficient dissipator is a metal case with an internal and external dull-black finish.

621.38: 621.317.2 1416

A Laboratory for Basic Electronics—P. M. Honnell and W. E. Strohm. (*Elec. Eng.*, vol. 65, pp. 75-80; February, 1946.) A description of the 140-position electronics laboratory installed at the U. S. Military Academy. A central switchboard distributes alternating or direct voltage, including audio and radio frequency up to 18 megacycles per second, to any of twelve benches, each of which has several student positions equipped with its own switchboard. Protective measures include automatic isolating of small sections to facilitate fault tracing.

621.394/.395].653+531.4+539.62 1417

The Physics of Rubbing Surfaces—Bowden. (*See 1219.*)

621.396/.397](058.7) 1418

1945 Electronic Engineering Directory—(*Elec. Ind.*, vol. 4, December, 1945.) A 56-page directory of United States sources of supply of radio and allied equipment. A supplement giving names of patent attorneys and consulting engineers appears in *Elec. Ind.*, vol. 5, pp. 98, 100; January, 1946.

621.396.62.017.72 1419

Ventilation Problems—W. Tusting. (*Wireless World*, vol. 52, pp. 72-75; March, 1946.) Suggests that the need for dissipating the heat (60 to 200 watts) generated by radio receivers is not always given due consideration in the early design stage. Excessive temperature rise may reduce component life. It is also liable to cause considerable frequency drift. The provision of unimpeded channels for air flow around tubes is the chief recommendation.

621.396.9: 061.6 1420

History and Activities of the Radiation Laboratory of the Massachusetts Institute of Technology—DuBridge. (*See 1251.*)

621.38 1421

Electronics for Engineers [Book Review]—J. Markus and V. Zeluff (editors). McGraw-Hill Book Co., New York, N. Y., 1945, 390 pp., \$6.00 (*Elec. Eng.*, vol. 65, p. 98; February, 1946.) A collection of 142 articles, reference sheets, charts, and graphs reprinted from *Electronics*.

ANTENNA WITH NOMINAL POWER GAIN OF 9!

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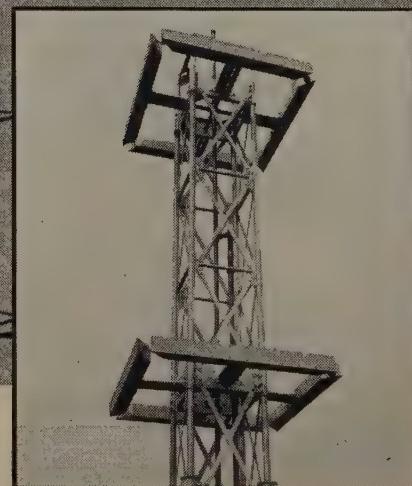
88 to 108 megacycles. Only one predetermined stub adjustment per loop changes it for any frequency in this band. Also, antenna array may be fed in two sections with separate coaxial lines to allow for emergency auxiliary operation.

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SECTION MEETINGS

ATLANTA

"The Phasitron and Its Operation," by J. M. Comer, Jr., General Electric Company; March 15, 1946.

BOSTON

"Broad-Band Antennas," by Andrew Alford, Consulting Engineer; April 26, 1946.

CHICAGO

"Relative to the Betatron," by Donald W. Kerst, University of Illinois; April 13, 1946.

"New Slot Antenna," by Edward C. Jordan, University of Illinois; April 13, 1946.

"Radio Communications—20 Kilocycles to 2000 Megacycles," by C. W. Hansell, RCA Laboratories; April 19, 1946.

"Microwave Developments," by W. G. Hawkins, Sperry Gyroscope Company; April 19, 1946.

CINCINNATI

"Deflection-Type High-Voltage Supplies for Television Receivers," by Madison Cawein, The Farnsworth Company; April 16, 1946.

CLEVELAND

"35-Millimeter Television Projection," by E. D. Cook, General Electric Company; April 25, 1946.

COLUMBUS

"Generation of Centimeter Waves," by Homer Hagstrom, Bell Telephone Laboratories; March 19, 1946.

DALLAS—FT. WORTH

"Radar for Bombing," by G. R. Frantz, Bell Telephone Laboratories; April 12, 1946.

DAYTON

"Television Equipment for Guided Missiles," by C. J. Marshall and Leonhard Katz, Air Materiel Command; April 18, 1946.

"Modulation Measurements of Low-Level Carriers," by L. A. Regnier, J. C. Noble and Seymour Krevsky, Air Materiel Command; April 18, 1946.

"Aircraft Radio and Weather," by E. L. Cleveland, Air Materiel Command; April 18, 1946.

"Wire versus Disk Recorders for Military Aircraft," by Harry Schecter, Air Materiel Command; April 18, 1946.

Election of Officers, April 18, 1946.

DETROIT

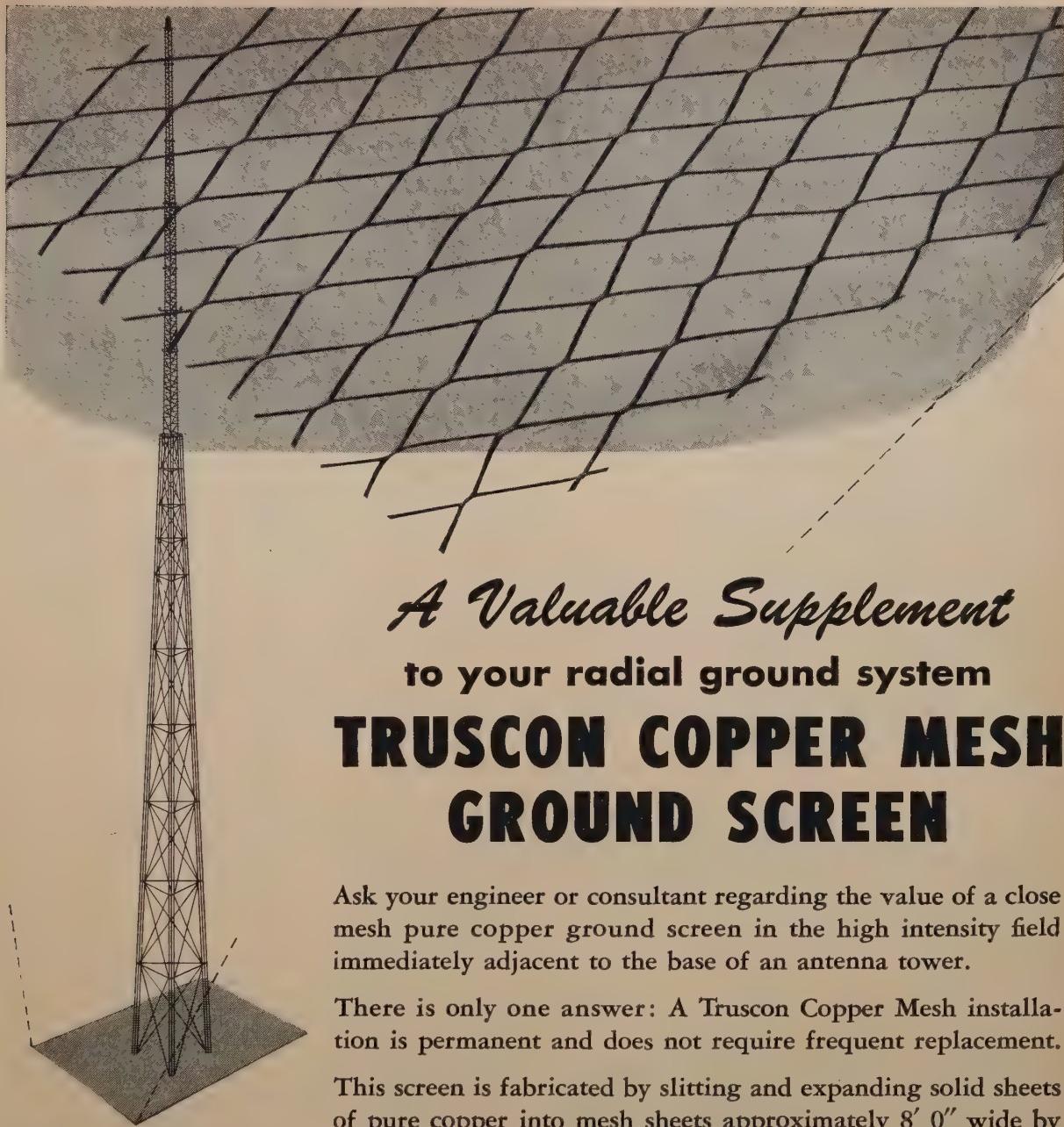
"Operation of 'ABSIE,'" by R. T. Pennebaker, Station WWJ; April 19, 1946.

HOUSTON

"Radar for Bombing," by G. R. Frantz, Bell Telephone Laboratories; April 9, 1946.

"The Development of the Proximity Fuze," by W. H. Carter, Jr., The Schlumberger Well Surveying Corporation; April 16, 1946.

(Continued on page 40A)



A Valuable Supplement
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**TRUSCON COPPER MESH
GROUND SCREEN**

Ask your engineer or consultant regarding the value of a close mesh pure copper ground screen in the high intensity field immediately adjacent to the base of an antenna tower.

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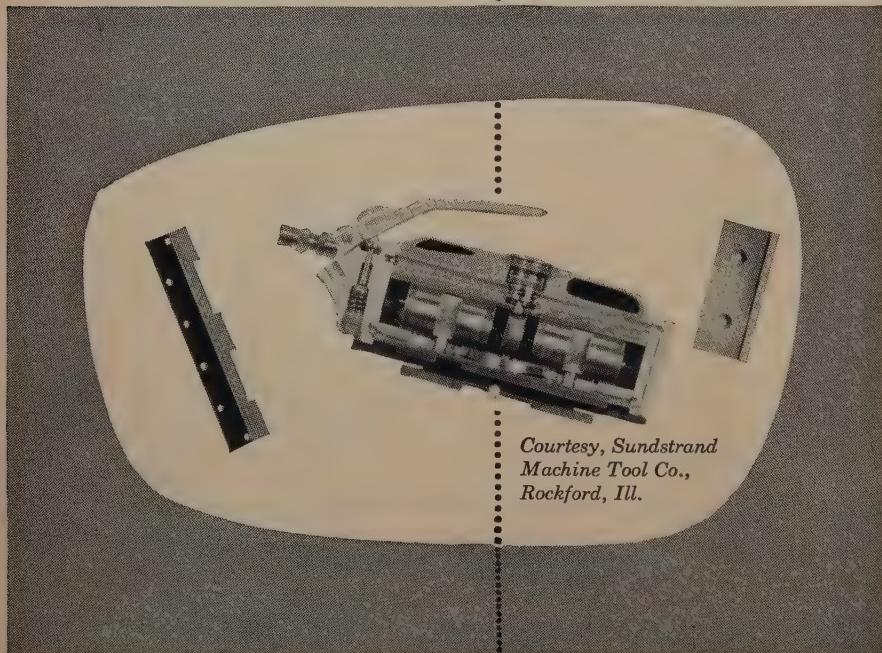
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(Continued from page 38A)

LONDON

"Electron-Microscope Technical Details," by S. G. Ellis, University of Toronto; February 22, 1946.

"Principles and Applications of Induction Heating," by D. R. Hay, University of Western Ontario; March 15, 1946.

"An Improved Vacuum-Tube Voltmeter," by G. Lang, University of Western Ontario; March 13, 1946.

"Pulse-Time Modulation," by W. W. Loucks, University of Western Ontario; March 15, 1946.

"Pulse-Time Modulation," by L. Libby, Federal Radio and Telephone Company; April 3, 1946.

LOS ANGELES

"Theory and Application of Intermodulation Tests," by J. K. Hilliard, Altec-Lansing Company; March 19, 1946.

"Recent Developments at Princeton Laboratories," by Harry Olsen and Vladimir Zworykin, RCA Laboratories; March 26, 1946.

MONTREAL

"Transatlantic Aeronautical Communication and Navigation," by S. S. Stevens, Trans-Canada Air Lines; April 10, 1946.

"Applications of Radio in Geophysical Prospecting," by H. G. I. Watson, McGill University; April 24, 1946.

Election of Officers, April 24, 1946.

PHILADELPHIA

"Technical Aspects of the ENIAC," by J. W. Mauchly, Moore School of Electrical Engineering, University of Pennsylvania; April 4, 1946.

"Technical Aspects of the ENIAC," by J. P. Eckert, Jr., University of Pennsylvania; April 4, 1946.

PITTSBURGH

"Pulse-Time-Modulated Multiplex Radio-Relay Terminal Equipment," by D. D. Grieg, Federal Telecommunications Laboratories; March 11, 1946.

ROCHESTER

"Television Equipment for Guided Missiles," by C. J. Marshall and Leonhard Katz, Air Materiel Command; April 11, 1946.

ST. LOUIS

"Electronic Applications in Medical Research," by G. M. Schoepfle, Washington University Medical School; April 26, 1946.

SAN DIEGO

"A New Frequency-Modulation Frequency-Control Circuit," by W. U. Dent, Westinghouse Electric Company; April 3, 1946.

SAN FRANCISCO

"The Phasitron and Its Use in Frequency-Modulation Transmitters," by F. P. Barnes, General Electric Company; February 13, 1946.

(Continued on page 42A)

Type 710-A

370 to 560 Mc



Type 734-A

1200 to 3750 Mc



RCA Signal Generators for u-h-f jobs

These signal generators may just fill the bill for some of your ultra-high-frequency development work.

The Type 710-A provides an r-f signal of a known frequency and amplitude for easily obtaining the data needed to check the performance of high-frequency devices. This instrument provides smooth and complete attenuation throughout its range, plus precision frequency control.

Output frequency: 370 to 560 megacycles—just right for citizen's radio-phone and other experimental and

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These signal generators are available for immediate shipment—as long as stock lasts.

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JOHNSON Pressurized Capacitors offer you maximum capacity with minimum size and cost.

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(Continued from page 40A)

"Radar Countermeasures," by F. E. Terman, Stanford University; March 1, 1946.

"Aircraft Use of Loran Radio Equipment," including display of equipment and Army training film, by W. H. Queen, United Air Lines; April 3, 1946.

"Fundamental Aspects of Color in Television and the Use of Ultra-High Frequencies for Television Broadcasting," by P. C. Goldmark, Columbia Broadcasting System; April 22, 1946.

TORONTO

"The Role of the Ionosphere in Radio Communication," by N. Rostoker, University of Toronto; February 25, 1946.

"Cathode Follower," by G. F. G. Weeden, University of Toronto; February 25, 1946.

"Vacuum-Tube Voltmeters," by G. R. Slemon, University of Toronto; February 25, 1946.

"Some Factors Involved in Sound Reproduction," by H. Goldin, Dominion Sound Equipments, Ltd.; March 25, 1946.

SUBSECTIONS

SOUTH BEND

"History, Development, and Use of Coaxial Cable," by R. Krueger, American Phenolic Company; January 17, 1946.

"Review of Communications in The China-Burma-India Theater," by W. F. Soules, Electro-Voice Corporation; February 28, 1946.

MEMBERSHIP

The following transfers and admissions were approved on May 1, 1946:

Transfer to Senior Member

Bossart, P. N., Union Switch and Signal Co., Swissvale, Pittsburgh 18, Pa.
Briggs, M. R., 34 Holmehurst Ave., Catonsville 28, Md.

Brownell, G. T., Majestic Radio and Television Corp., St. Charles, Ill.

Campbell, R. D., Room 1705-A, 195 Broadway, New York 7, N. Y.

Coles, F. A., 45 Christopher St., New York 14, N. Y.

Conron, W. H., 322 Estaugh Ave., Haddonfield, N. J.

Crawford, A. B., Box 107, Red Bank, N. J.

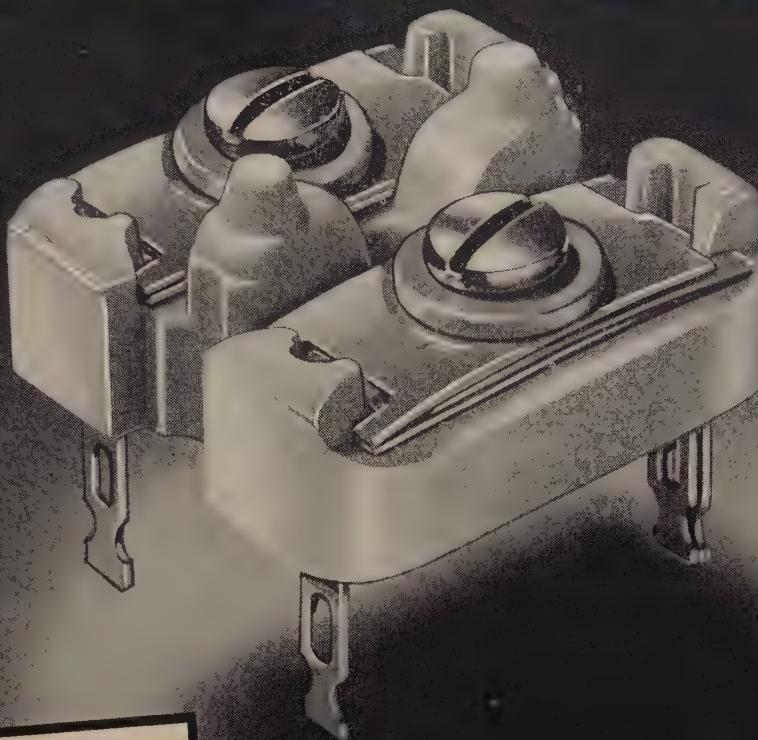
Farel, V. M., RCA International Division, 745 Fifth Ave., New York 22, N. Y.

Fischer, H. B., 463 West St., New York 14, N. Y.

Gano, A. S., 38 Cummings Ave., White Plains, N. Y.

(Continued on page 44A)

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Hammann, P. L., Bell Telephone Laboratories, Whippany, N. J.
Hollingsworth, L. M., 36 Highland Ave., Cambridge 39, Mass.
Hunter, T. A., 1164 E. Court St., Iowa City, Iowa
Jaffe, D. L., Polarad Electronics Co., 135 Liberty St., New York, N. Y.
Nevitt, H. J. B., 3311—82 St., Jackson Heights, L. I., N. Y.
O'Neill, G. D., 34-10 Linden Pl., Flushing, L. I., N. Y.
Peterson, G., Box 1360, Bartlesville, Okla.
Pierce, J. R., Bell Telephone Laboratories, Inc., 463 West St., New York 14, N. Y.
Price, L. M., Radio Valve Company of Canada, 189 Dufferin St., Toronto 1, Ont., Canada
Reintjes, J. F., 354 Fourth Ave., Troy, N. Y.
Siemens, R. H., Avenida Forest 1535, Buenos Aires, Argentina
Smith, P. C., 179 Ido Ave., Akron 1, Ohio
Stout, G. P., 324 Broadmoor Rd., Baltimore 12, Md.
Waynick, A. H., 423 S. Pugh, State College, Pa.
Zahl, H. A., 320 Bath Ave., Long Branch, N. J.

Admission to Senior Member

- Allsop, R. C., 30 Trafalgar Ave., Roseville, Sydney, New South Wales, Australia
Arditi, M., 157 W. 57 St., New York 19, N. Y.
Brand, P. M., 27 Mill Cove, Lambton Mills, Toronto 9, Ont., Canada
Dixon, G. P., International Telephone and Telegraph Corp., 67 Broad St., New York 4, N. Y.
Frantz, G. R., 463 West St., New York 14, N. Y.
Gillson, M. H., 19 Olyphant Dr., Morristown, N. J.
Hanson, G. N., Meadow Lane, North Shore Acres, Glen Cove, L. I., N. Y.
Kohlhaas, H. T., 67 Broad St., New York 4, N. Y.
Lubkin, S., 1601 Mayland St., Philadelphia 38, Pa.
Wagenseil, W., 101 Monterey Ave., Pelham 65, N. Y.

Transfer to Member

- Begley, W. W., 1413—21 St., N.W., Washington 6, D. C.
Bennett, R. M., Jr., 7443 Cromwell Dr., Clayton, Mo.
Berkley, J. B., Bureau of Ships, Navy Department, Washington 25, D. C.
Brokaw, H. R., 2553 Montrose Ave., Montrose, Calif.
Broman, H. F., 1236 New York Ave., Brooklyn 3, N. Y.
Clewes, T. W., 202 Frederick St., Kitchener, Ont., Canada

(Continued on page 46A)

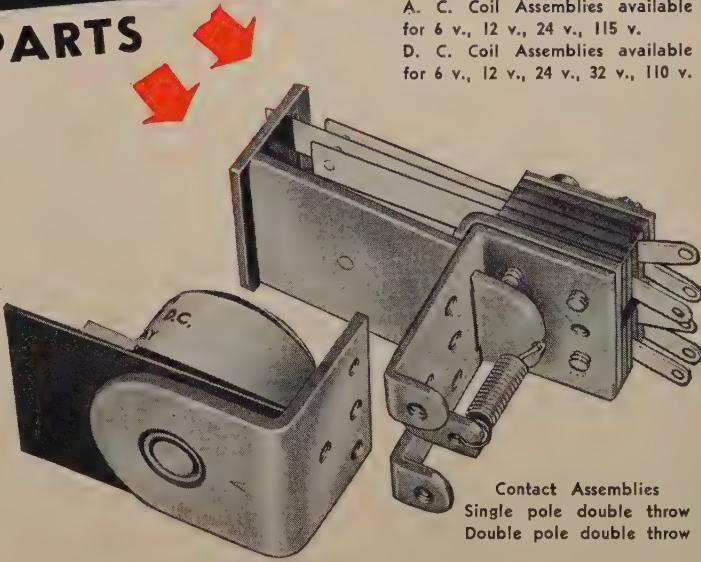
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A RELAY BY GUARDIAN with Interchangeable Coils

BUILT IN TWO PARTS

★ Two basic parts—a coil assembly and a contact assembly—comprise this simple, yet versatile relay. The coil assembly consists of the coil and field piece. The contact assembly consists of switch blades, armature, return spring, and mounting bracket. The coil and contact assembly are easily aligned by two locator pins on the back end of the contact assembly which fit into two holes on the coil assembly. They are then rigidly held together with the two screws and lock washers. Assembly takes only a few seconds and requires no adjustment on factory built units.



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Single pole double throw
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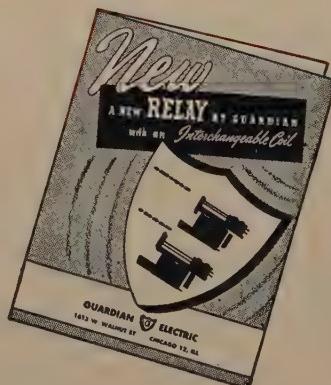
See it today! ... this amazing new relay with interchangeable coils. See how you can operate it on any of nine different a-c or d-c voltages—simply by changing the coil. Ideal for experimenters, inventors, engineers.

TWO CONTACT ASSEMBLIES

The Series 200 is available with a single pole double throw, or a double pole double throw contact assembly. In addition, a set of Series 200 Contact Switch Parts, which you can buy separately, enables you to build dozens of other combinations. Instructions in each box.

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Four a-c coils and five d-c coils are available. Interchangeability of coils enables you to operate the Series 200 relay on one voltage or current and change it over to operate on another type simply by changing coils.



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The Model 650 is a modern accurate and complete instrument for detecting faulty condensers—Electrolytic, Paper or Mica. New method for Leakage

Test reveals otherwise unnoticed condenser defects.

Scale is Glass Enclosed and is equipped with the new Jackson Scale Expander indicating pointer—doubles effective scale length.

Measures All Values— Direct reading in Microfarads.

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.001 to .1 mfd.	50 to 1000 mfd.

Measures Power Factor on direct reading dial. Power Factor range calibrated from 0 to 60%.

Complete Selection of Test Voltage. 20 volts to 500 volts.

Electron Ray Tube indicates exact balance or shows if leakage is present.

Instantaneous Leakage Indication— Counting of flashes eliminated. No other guess-work with this modern tester. Has special built-in amplifier stage which actually responds to slightest leakage, if present. Thus all leakage defects may be located.

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dePasquale, R. H., 1475 Broadway, New York, N. Y.

Ducore, H., 404 S. Atkins Ave., Neptune, N. J.

Duerden, F., 112 Springfield Park Ave., Chelmsford, Essex, England

Eichwald, B., 2054 E. 21 St., Brooklyn 29, N. Y.

Hedberg, C. A., 83 Center Ave., Chatham, N. J.

Heister, C. F., 809 U. S. Court House, Federal Communications Commission, Kansas City 6, Mo.

Henderson, A. B., 9 Cushing Ave., Dayton 9, Ohio

Higgins, F. V., 5716—26 St., N., Arlington, Va.

Holets, L. L., 618—32 St., N.E., Cedar Rapids, Iowa

Holetz, A. C., 219-11—118 Ave., St. Albans 11, L. I., N. Y.

Johnson, P. B., 200 McKinley Dr., Belleville, Ill.

Kamm, G. N., 35 Conant Hall, Harvard University, Cambridge 38, Mass.

Laporte, J. M., Box 411, Sackville, N. B., Canada

Martel, C. W., 6 First St., Chelmsford, Mass.

McCoy, R. E., 5607 N. E. Garfield Ave., Portland 11, Ore.

McLeish, C. W., RFD 1, Billings Bridge, Ont., Canada

Mounce, G. R., Billings Bridge, Ont., Canada

Oliver, B. M., Bell Telephone Laboratories, 463 West St., New York 14, N. Y.

Paine, H. G., 5 Elmira St., S.E., Washington 20, D. C.

Peterson, R. A., 405 Belmont Ave., Haddonfield, N. J.

Purcell, R. H., 403 Hudson St., New York 14, N. Y.

Quaranta, S. L., 203 N. Third Ave., Highland Park, N. J.

Rao, V. V. L., Kilpauk P. O., Madras, South India

Roue, J. E., 244 Spring Garden Rd., Halifax, N. S., Canada

Ruth, C. G., 354 Princess Ave., London, Ont., Canada

Schwarzlose, P. F., 212 Electrical Engineering Laboratory, University of Illinois, Urbana, Ill.

Shirling, G. K., 1523 E. 59 St., Kansas City 4, Mo.

Smith, P. L., Naval Research Laboratory, Washington 20, D. C.

Smith, R. L., WRGB, 60 Washington St., Schenectady 5, N. Y.

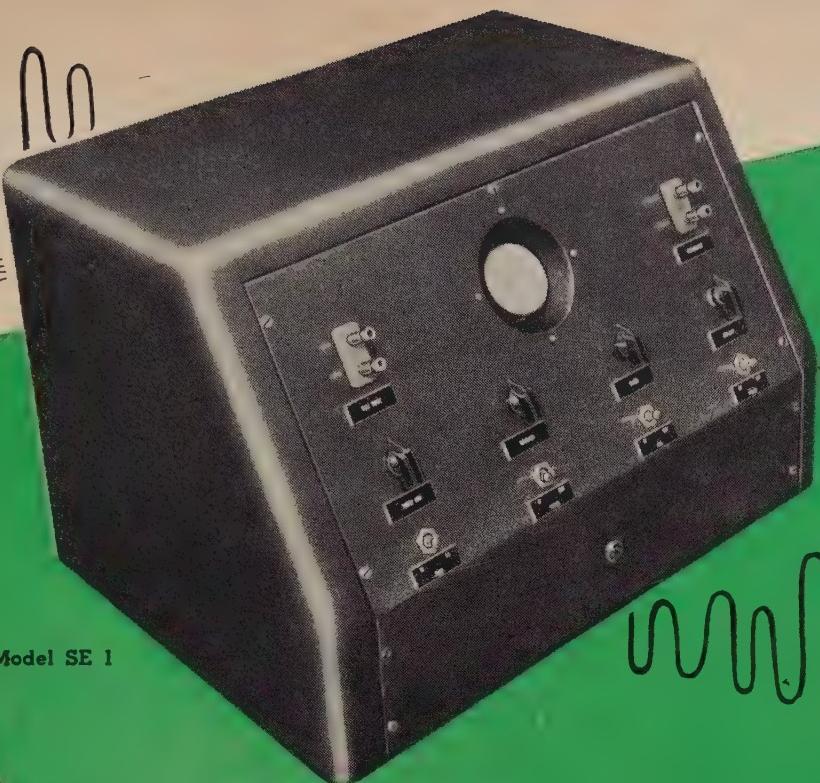
Soward, R., Box 552, Greenwood, Miss.

Stone, R. P., RCA Laboratories, Princeton, N. J.

Tidball, F. E., 5806—63 Ave., East Riverdale, Md.

Van Alstyne, A. B., Richfield, Wis.

(Continued on page 48A)



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This unit also available with 60-120-1000 cycle oscillator built in.

Model SE 1

SHERRON CATHODE RAY NULL DETECTOR

A Laboratory Precision Instrument Built for Production Application

THE SHERRON CATHODE RAY TUBE NULL DETECTOR
is a precision laboratory instrument designed for all A.C.
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- It is both a high impedance detector and an undistorted, filtered and shielded source of 1000 cycles per second.
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- Bridge detector impedance is 1 megohm.
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- Self protection from overloading is included in this unit. Under any input conditions, the circuit cannot be overloaded or damaged.
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- Automatic control of the gain precludes the necessity of resetting while adjusting bridge for balance.

*Every precision type Bridge requires
a Sherron Precision Null Detector*

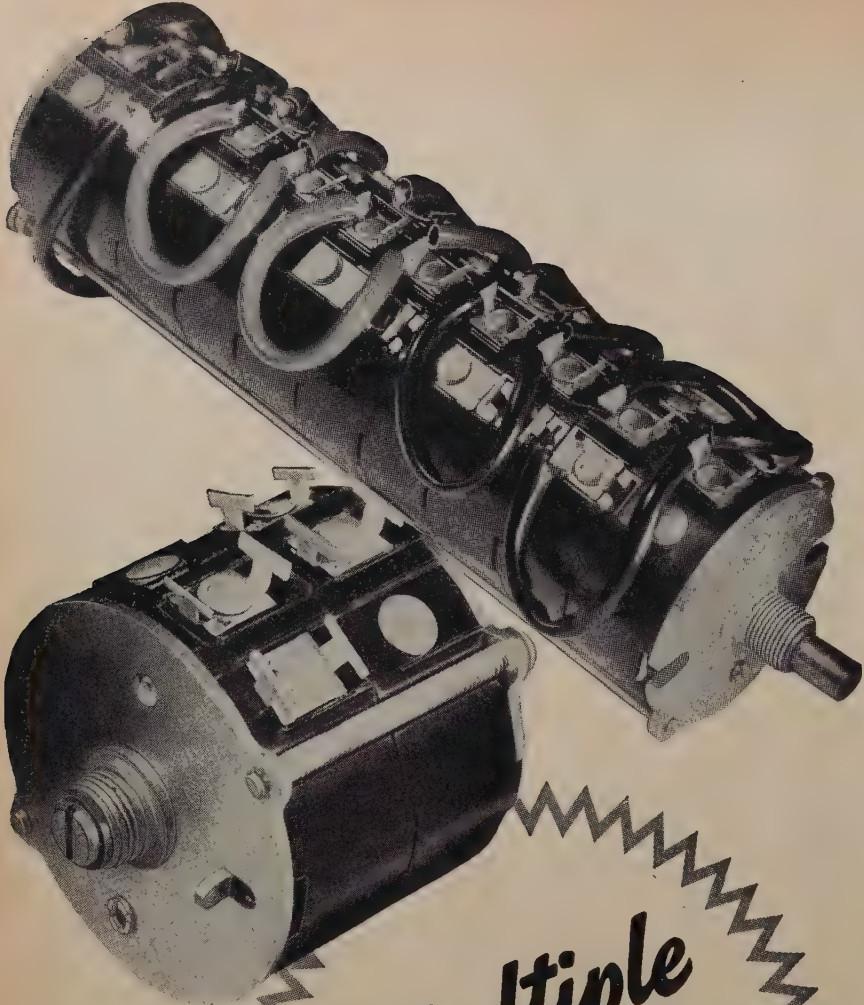


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Each unit can be wound to precise circuit requirements, as to resistance, taper, tap, hop-off.

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★ Submit your problem!

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Van Horn, J. E., 202 N. Piedmont St., Arlington, Va.
Waugh, G. T., General Electric Co., Bldg. 269, Schenectady, N. Y.
Weimer, E. W., 1305—46 St. S.E., Washington 19, D. C.
Wells, M. T., Naval Air Station, Quarters K, Quonset Point, R. I.
Wilby, E. W., RCA Laboratories, 589 E. Illinois St., Chicago 11, Ill.
Wright, O. L., 239 College St., Puente, Calif.

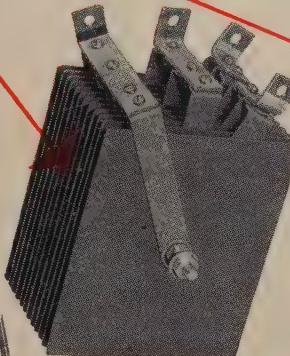
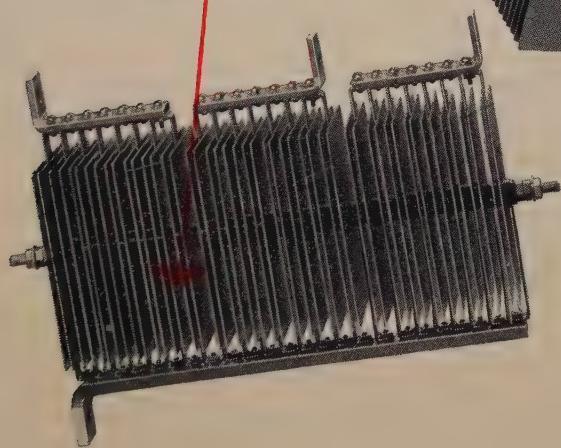
Admission to Member

Baasch, H. C., 105 Harcourt Ave., Bergenfield, N. J.
Berkheimer, R. H., Box 124, RFD 1, Gig Harbor, Wash.
Bluestone, E. S., 83-57—118 St., Kew Gardens 15, L. I., N. Y.
Carpantier, V. J., 102 S. Kilmer St., Dayton 7, Ohio
Cone, J. H., 38 St. Luke's Pl., Montclair, N. J.
Denius, H. R., 48 Merritt Ave., White Plains, N. Y.
Doolittle, H. D., 48 Eighth St., Stamford, Conn.
Etches, E. D., 31 Spruce Court, Toronto 2, Ont., Canada
Frankel, H., 3737 Locust St., Philadelphia 4, Pa.
Gaston, E. E., 1820 Oak Park Ave., Berwyn, Ill.
Godfrey, X. W., 128 Linden Ave., Haddonfield, N. J.
Goldberg, W. P., 309 Westwood Ave., Long Branch, N. J.
Grossmann, J. J., American Telephone and Telegraph Co., Room 1538, Union Commerce Bldg., Cleveland 14, Ohio
Gruol, J. W., 1714 W. Tioga St., Philadelphia 40, Pa.
Halligan, E. P., 7631 N. Eastlake Terrace, Chicago 26, Ill.
Hopkins, C., 20 Chauncy St., Cambridge, Mass.
Jacobs, G., 197 Connecticut Ave., New London, Conn.
King, D. D., 38 DeWolfe St., Cambridge 38, Mass.
Kinney, W. E., 3519 N.W. 13 Ave., Miami 37, Fla.
Lee, H., 611 Church St., Ann Arbor, Mich.
Lindenberg, S., 1576 Unionport Rd., New York 62, N. Y.
Lingren, C. E., 805 Davenport Rd., Toronto 4, Ont., Canada
McLaughlin, W. J., 2367 Burdett Ave., Troy, N. Y.
Paterson, S. G., 155 St. George St., Toronto, Ont., Canada
Patterson, S., 205 Shawnee Rd., Merion Golf Manor, Ardmore, Pa.
Pearlman, L. S., 2 Lewiston Court, Poquonock Bridge, Conn.
Rollman, R. F., A. B. DuMont Laboratories, Inc., Passaic, N. J.
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- ✓ High efficiency per unit weight.
- ✓ Hermetically sealed assemblies available.
- ✓ From 1 volt to 50,000 volts RMS.
- ✓ From 10 micro-amperes to 10,000 amperes.
- ✓ Economical—No maintenance cost.



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Positions Wanted

(Continued from page 52A)

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Caltech graduate, with development, test, installation, and administrative experience on instrument landing equipment, radio, and radar, consisting of 1 year industry, 2½ years Signal Corps Officer and 10 years practical radio. Box 2W.

ENGINEER

Engineering graduate, age 38, desires permanent position, executive or administrative responsibilities. 11 years commercial engineering experience on radio and television receivers, signal generators, etc. 5 years military experience on airborne radio and radar. Box 3W.

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Skilled radio engineer located in South Africa desires to join staff of radio factory planned for establishment in that country. Box 5W.

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(Continued from page 48A)

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Bellew, H. P., 1736 W. Erie Ave., Philadelphia 40, Pa.

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Borden, T. G., 2200 Cheverly Ave., Cheverly, Hyattsville, Md.

Brodhead, W. M., 126 Newbury St., Boston 16, Mass.

Bulmore, H. R., Simonds Saw and Steel Co., Lockport, N.Y.

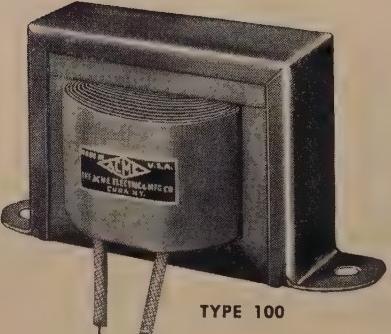
Call, S. S., 69 Seymour Ave., Springfield, Mass.

Calnon, D. C., Jr., 2835 N.E. 55 Ave., Portland 13, Ore.

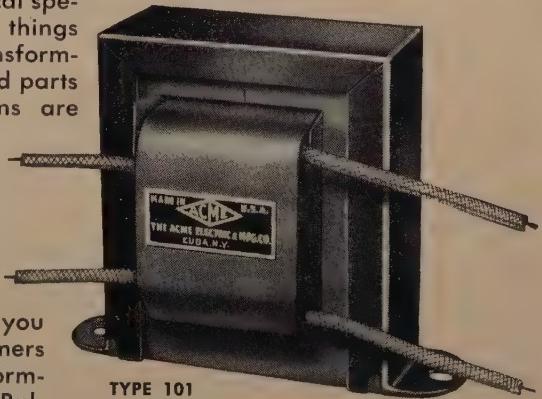
(Continued on page 40A)

HOW MANY VARIATIONS ARE THERE TO A STANDARD DESIGN

Acme Electric transformers are designed to basic standards to which variations can be adapted to exactly meet the requirements of the application. For example, Mounting Type 100 is for horizontal mounting while type 101 is for vertical mounting, yet both are basically identical. And in either case, one or both mounting legs may be turned down for side mounting to save space. The number of leads or terminals may also be varied to comply to the electrical specifications desired. All things considered, Acme transformers made from standard parts to special specifications are available in hundreds of ratings and to exactly the physical dimensions, design and electrical characteristics you require. Acme Transformer Engineers will be glad to assist you by designing transformers to improve the performance of your product. Bulletin 168 gives more details.



TYPE 100



TYPE 101

THE ACME ELECTRIC & MFG. CO.
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Aeme  **Electric**

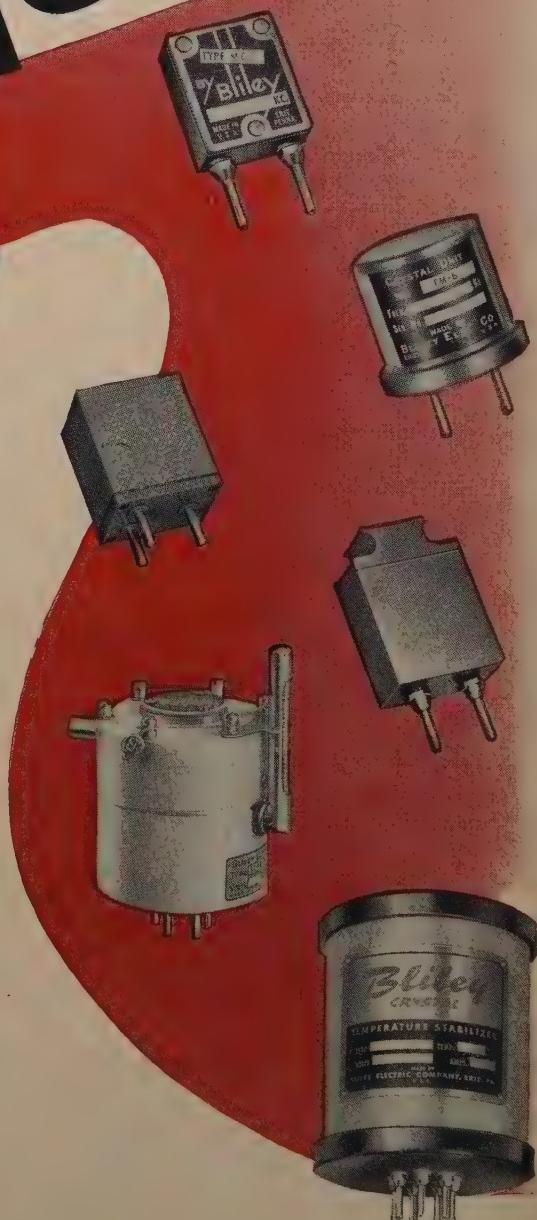
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Every product that enjoys the full confidence of those who use it has its "priceless ingredient." In Bliley crystals it's "techniquality."

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Bliley CRYSTALS

BLILEY ELECTRIC COMPANY • UNION STATION BUILDING, ERIE, PENNSYLVANIA

Proceedings of the I.R.E. and Waves and Electrons

June, 1946

55A



(Continued from page 54A)

- Carlan, L. B., 154 Beach 68 St., Arverne, L. I., N. Y.
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Carman, E. B., 68 Homestead Ave., Bridgeport 5, Conn.
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Celnar, P. J., 1556 Myrtle Ave., Columbus 3, Ohio
Chernoff, B., RFD 3, Newburgh, N.Y.
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Cotton Mill 9, 140 Macao Rd., Shanghai, China
Chiles, W. R., 2829 S. W., 13 St., Miami 35, Fla.
Cobin, F., 158 E. Seventh St., New York 9, N. Y.
Cole, L. S., 696 E. Fourth North St., Logan, Utah
Corby, L. A., Hefco Agencies, 53 Yonge St., Toronto, Ont., Canada
Cox, L. E., 308 S. Jefferson Ave., Springfield, Mo.
Crosby, H. K., 941 Hillside Ave., Norfolk 3, Va.
Curtice, J. D., Park Lee Apartments, 1630 Park Road, N. W., Washington 10, D. C.
Dean, C. M., 16 Oak Grove, Manchester, Conn.
Decker, A. P., KFFA, Helena, Ark.
Desmond, W. F., Suite 722, 38 S. Dearborn St., Chicago 3, Ill.
de Wolfe, G. C., 117-A North Park Ave., Montebello, Calif.
Dorratcague, P. E., 18 Oak Grove Dr., Baltimore 20, Md.
Eckert, J. A., Jr., 5514 Ruthelen St., Los Angeles 37, Calif.
Eichert, E. S., Moore School of Electrical Engineering, 33 and Walnut Sts., Philadelphia 4, Pa.
Fahsing, W. F., 230 E. 25 St., New York 10, N. Y.
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Figlia, J. R., Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, L. I., N. Y.
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Fowler, C. A., Box 32, East Norwich, L. I., N. Y.
Fox, C. A., 1712 W. 70 St., Los Angeles 44, Calif.
Frazier, R. L., Hq., Air Matériel Command, TSEWS All Weather Flying Division, Wright Field, Ohio
Futchik, A. J., 735 Lime Ave., Long Beach 2, Calif.
Garber, T., 290 Massachusetts Ave., Cambridge 39, Mass.
Golby, A. R., 231 Edward St., London, Ont., Canada
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(Continued on page 58A)

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DIVISION OF ESSEX WIRE CORPORATION

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"Better tube life . . . less production shrinkage" with ZIRMET, says Raytheon

Interesting new development by Raytheon is a mercury vapor rectifier with Zirmet acting in the role of a built-in vacuum pump.

"Zirmet" is Foote Mineral Company's 99.9+% pure ductile zirconium.

Small Strip of Metal Effective

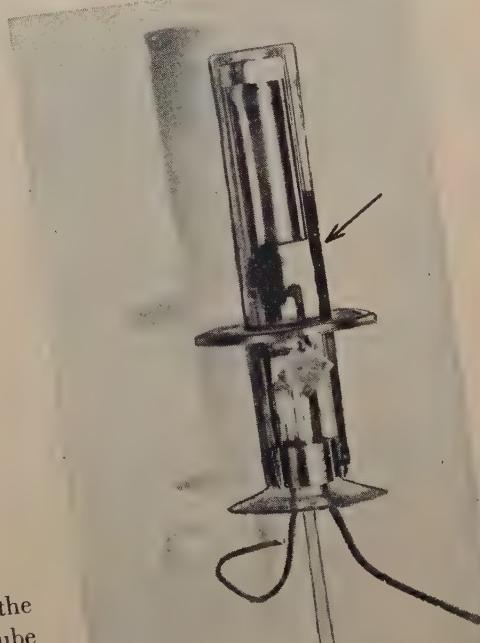
The Raytheon rectifier requires only a ribbon of Zirmet $\frac{1}{8}$ " wide x 1" long x .003" thick for its job as a getter.



The Zirmet ribbon is welded to the cathode shield support. In normal tube operation the Zirmet reaches a temperature of about 650°C.

Not Affected by Mercury Vapor

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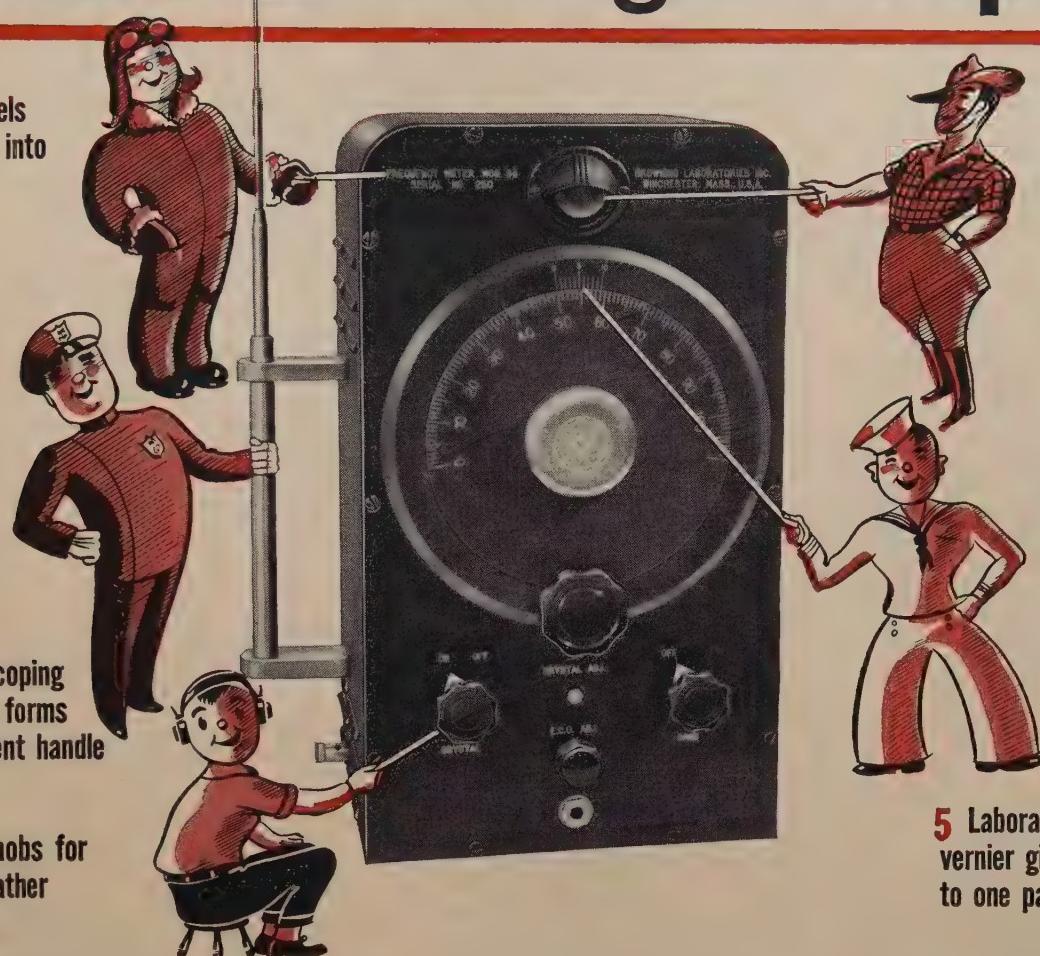
(Continued from page 56A)

- Gross, F. A., 57 Rockland St., Swampscott, Mass.
 Gross, V., 1009 Lincoln Pl., Brooklyn 13, N. Y.
 Gruenfelder, R. J., 111 S. Third St., New Hyde Park, N. Y.
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 Horowitz, S., 1673—64 St., Brooklyn N. Y.
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 Jacobson, N., 1697 Andrews Ave., Bronx, N. Y.
 Jeffers, L. B., Sr., 1504 ½ Ash Ave., Independence, Mo.
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 Keast, A. K., 844 Waller St., San Francisco, Calif.
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 Kups, E. F., 552 S. 19 St., Newark 3, N. J.
 Lang, H. J., Box 1663, Santa Fe, N. M.
 Mi, L., N.R.C. Office of China, 111 Broadway, New York 6, N. Y.
 Lewis, C. W., Jr., 111 Union St., Schenectady 5, N. Y.
 Liddiard, G. E., 7626 Fay Ave., La Jolla, Calif.
 Lindley, L. E., Sylvania Electric Products, Inc., Emporium, Pa.
 Lipman, N., 611 Bond St., Asbury Park, N. J.
 Maisel, W. A., 6516 N. E. 22 Ave., Portland 11, Ore.
 Marshall, R. T., 211 Hazard St., Houston 6, Tex.
 McCoy, E. W., Jr., 56 Elliott Ave., Yonkers 5, N. Y.
 McKay, H. B., 1379—35 Ave., San Francisco 22, Calif.
 Michaels, H. M., 1455 Fulton Ave., Bronx 56, N. Y.
 Miller, O. M., Vandalia Rd. RFD 5, Des Moines 17, Iowa
 Milton, O., Westinghouse Electric Corp., X-Ray Division, 233 S. St. Francis St., Wichita, Kan.
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 Monell, M. B., 1722 Asbury Dr., Pasadena 7, Calif.

(Continued on page 60A)

Another Browning Development

1 All labels engraved into panel



2 Telescoping antenna forms convenient handle

3 Big knobs for cold weather handling

6 New non-jamming vernier drive for fine adjustment

9 Audio output for audibly detecting beats

7 Uses WWV as primary standard

10 110-115 AC-DC operation — checks AM or FM

4 Visual determination of zero beat by cathode ray indicator

5 Laboratory-type dial with vernier gives readability to one part in one thousand

8 Rugged steel cabinet and $\frac{1}{8}$ " aluminum panel

BROWNING'S Model S-4 Frequency Meter was designed especially for marine, police, aircraft, fire department, and other special service radio operators, who must be certain that transmitters are on frequency.

Completely new, it incorporates all the features that supervisors of emergency radio systems have requested — plus many new refinements perfected during our war experience in designing high-precision radar test equipment.

For example, we have included a vernier on the new laboratory-type scale, permitting reading accuracy to one part in one thousand. A telescoping antenna has been added to the side of the case. When telescoped, it forms a convenient carrying handle. Big, easy-to-hold

knobs let you operate the meter with gloves on, in cold weather.

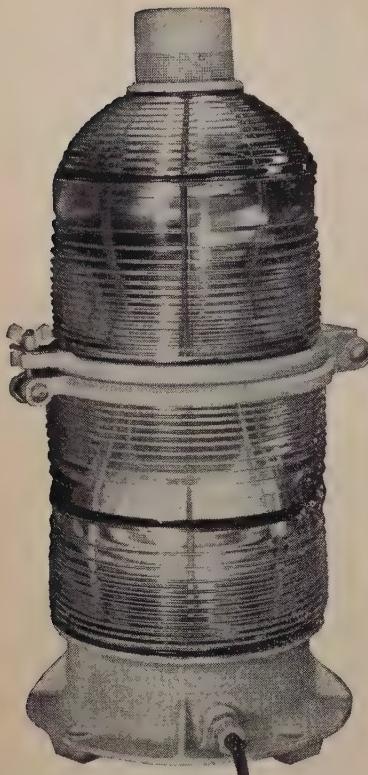
The highest degree of stability has been built into the Model S-4 by the use of improved circuits and voltage regulation within the unit. FCC requirements of plus or minus .00025% accuracy are exceeded by the crystal-controlled BROWNING Frequency Meter. Using 110-115 volt A.C. or D.C. current, it checks both AM and FM equipment.

The S-4 is custom built and hand calibrated for testing frequencies in any five bands from 1.5 to 100 mc., according to the user's requirements. For additional technical data and other information, address BROWNING LABORATORIES, Inc., Winchester, Mass.



BROWNING

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CODE BEACON FOR RADIO TOWERS

A 300 MM code beacon designed and built by ANDREW for lighting radio towers as aviation hazards. Required by the CAA on radio towers of 150 feet or greater in height. Two 500-watt prefocus lamps provide an intense light which passes through red pyrex glass filters and is radiated in a circular, horizontal beam by cylindrical fresnel lenses. Metal parts are made of light-weight cast aluminum, with hardware of corrosion-resistant bronze.

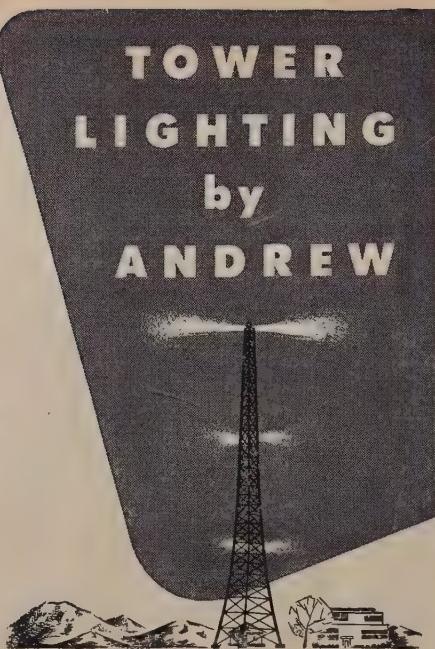


LIGHTING FILTER. The ANDREW Model 1803 lighting filter serves to connect the 60-cycle lighting voltage across the base insulator of a series excited tower without detuning the tower. Three windings provide for operation of code beacon and obstruction lights. Mica insulated by-pass condensers of ample current rating included. Also offered in weatherproof steel housing.

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of a Complete Line of
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OBSTRUCTION LIGHT. Type 661 is a 100-watt unit fitted with a red fresnel lens to concentrate the light in a nearly horizontal direction. Used in pairs at $\frac{1}{3}$ and $\frac{2}{3}$ levels on radio towers for aircraft warning.

BURNOUT INDICATORS. Highly damped meter with special wattmeter scale indicates when code beacons or obstruction lights need re-lamping.

FLASHERS. Designed to flash 300 MM code beacons at rate of 40 cycles per minute, as prescribed by government regulations. Flashers have 25-ampere contacts and condensers for radio interference elimination. Use K-10347 for one or two beacons; use K-10348 to maintain constant 2000-watt load with three beacons.

TIME SWITCHES. Switch tower lights on at sunset and off at sunrise. Special astronomic dial follows seasonal variations in sunset and sunrise time. Photo-electric models also available.

LAMPS. A complete stock of lamps for code beacons and obstruction lights is carried for the convenience of users. Available in a wide variety of filament voltages.



(Continued from page 58A)

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Nelson, P. H., 18 Rahway Rd., Millburn, N. J.

Newman, J. E., WDBJ, Roanoke 2, Va. Nifong, H. A., KAVE, Carlsbad, N. M. O'Neil, D. H. C., 5740 Bartmer Ave., St. Louis, Mo.

Pecar, A. J., 11824 Payton Ave., Detroit 24, Mich.

Perkins, R. W., 606 E. 80 St., Chicago 19, Ill.

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Phelps, W., 1710 Richmond Ave., Houston 6, Tex.

Phillips, F. S., 809 W. 32 St., Houston 8, Tex.

Plog, K., American Telephone and Telegraph Co., 4100 Bryan St., Dallas 1, Tex.

Poloway, A. A., 111 Luxton Ave., Winnipeg, Manit., Canada

Pritchard, D. A., 2496 Derbyshire Rd., Cleveland Heights 6, Ohio

Reiss, N. D., 7629 E. Jefferson Ave., Detroit 14, Mich.

Richards, R. R., 2350 Creston Ave., Bronx, N. Y.

Ritter, H. C., 5620 N. E. Cleveland Ave., Portland 11, Ore.

Robinson, J. C., 1422 San Jacinto St., Houston 2, Tex.

Rosenberg, S. L., 1312 Stratford Ave., New York 59, N. Y.

Russ, F. J., 557 Lebaum St., S. E., Washington 20, D. C.

Santino, L., 194 Gelston Ave., Brooklyn 9, N. Y.

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Schwenk, C. C., 3810 Gwynn Oak Ave., Baltimore 7, Md.

Seiler, N. B., 3518 W. 60 St., Chicago 29, Ill.

Sewell, C., Jr., Box 1663, Santa Fe, N. M. Shabeck, J. C. L., Jr., 101 Crescent St., Waltham 54, Mass.

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(Continued on page 62A)



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The Type 11 System combines a wide band (190 to 550 KC) LF Range Receiver and a VHF Transmitter with provision for 5-channel operation at the turn of a switch. The small separate control unit is located for convenience of operation and the major units remotely mounted. This avoids disturbance of normal weight and balance of the airplane and usually permits a short antenna lead-in. The complete antenna system consists of a single vertical rod 22 inches long and is furnished with the Type 11 System.

This compact ARC equipment is based on more than 18 years of design and development in the field of airborne radio and is a *quality* instrument for the operator who requires the basic essentials in aircraft communication and navigation facilities. Remember, when selecting the radio for your airplane, nothing but the best is good enough—specify ARC. For descriptive information and prices, write Aircraft Radio Corporation, Boonton, New Jersey.



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 Wheeler, R. B., Airborne Instrument Laboratory, Inc., 160 Old Country Rd., Mineola, L. I., N. Y.
 Wilcoxon, L., 2921 Simpson St., Evanston, Ill.
 Wilson, J. W., 12237 Morrison St., North Hollywood, Calif.
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 Witkin, E., State Hospital, Norristown, Pa.
 Wright, T. A., 3244 Valley Dr., Park Fairfax, Alexandria, Va.
 Wyman, J. E., Box 331, Brentwood, L. I. N. Y.
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 Younson, E. J., 120 Bede Burn Rd., Jarrold, County Durham, England
 Zamorano, A., 144 W. 82 St., New York 24, N. Y.
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We, at Stancor, apply this principle to our product . . . quality transformers. For we realize that any change in Stancor transformers, enabling us to capitalize on the peak demands, would mean a sacrifice in quality.

We're convinced, too, that this is your choice; that you, as a transformer user, in sustaining your valued position in the industry, endorse the Stancor policy of quality. In a sense, then, you dictate Stancor policy.

Like you, we are expending every effort to surmount today's knotty production and delivery problems, that we may soon be able to supply the same quality transformers . . . in ever increasing quantities.

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Jerome J. Kahn
PRESIDENT

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CORPORATION

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Westinghouse Resumes Fellowships

Westinghouse Electric Corporation has announced resumption of fellowships to young scientists for work on pure scientific research of their own choosing. L. W. Chubb (M'21-F'40), director of Westinghouse Research Laboratories, said applications have been forwarded to universities and government research laboratories to select three outstanding young men for a year's work at the Westinghouse Laboratories. The board of review for selecting appointees will include Dr. Chubb, and C. R. Hanna (M'28-SM'43), J. A. Hutcheson (M'28-SM'43), and Joseph Slepian (SM'45-F'45), associate directors. The group will also serve as an administrative staff for supervising and following work of the appointees.

Under the plan, young scientists having training equivalent to that represented by a doctor's degree from a recognized university are chosen to perform research which they themselves outline and initiate. The fellowship has a value of \$3300 a year, and the

(Continued on page 68A)

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... when you need resistors in a hurry !!!

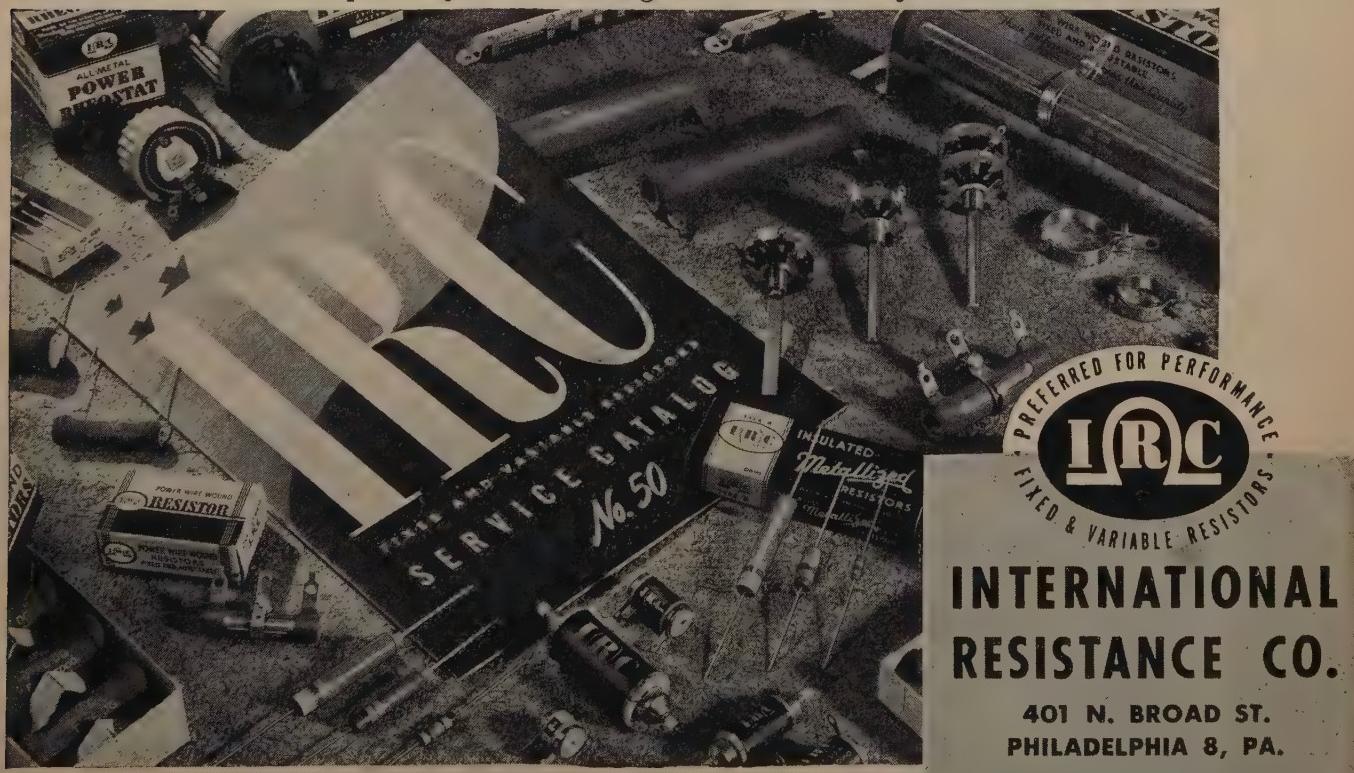
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Write to Dept.11-E for IRC Catalog #50 and names of local IRC Distributors.



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guides • Resonant Cavities • Antennas • Microwave Oscillators • Radar and Communication • Section Two is devoted to descriptions of Microwave Terms, Ideas and Theorems Index.

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SPECIFICATIONS:

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OUTPUT SYSTEM: 1 to 100,000 microvolts with negligible carrier leakage.

OUTPUT IMPEDANCE: Constant at 17 ohms.

MODULATION: 400 cycle internal audio oscillator. Deviation directly calibrated in two ranges: 0 to 30 kc. and 0 to 300 kc.

Can be modulated from external audio source.

Audio fidelity is flat within two db from d.c. to 15,000 cycles.

Distortion is less than 1% at 75 kc. deviation.

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PROMPT DELIVERY

Westinghouse Resumes Fellowships

(Continued from page 62A)

men may be reappointed for a second year. Considered important are investigations of the fundamentals of ferromagnetism and the properties of semiconductors; and problems in the fields of nuclear physics, conduction of electricity in gases, dielectrics, thermionics, applied mechanics, and chemical physics are also appropriate.

The discovery of photofission—the splitting of uranium atoms by high-energy gamma rays with a commensurate release of large amounts of energy—was made in 1940 by three Fellows appointed in 1938. W. E. Shoupp (SM'45), one of the codiscoverers, is now manager of the Laboratories' electronics department and has been active during the war in the development of radar devices and countermeasures. Another direct outcome of fellowship projects is the development of the transmit-receive box, a superspeed electronic switch used in radar equipment, one of whose coinventors is Sidney Krasik (M'43), presently electronics department section engineer. Sidney Siegel (S'43-A'44) magnetics department section engineer, has advanced the theories of magnetism and the knowledge of magnetic materials.

Industry Opens New Fields For Electron Tubes

After a quarter-century of service in the entertainment and communications field, the electron tube is now ready to realize its full, vast potentialities in peaceful commerce and industry, according to L. W. Teegarden vice-president in charge of the tube department of the Radio Corporation of America. The year ahead should be marked by a substantial start toward this realization. Eventually, the production of tubes for nonradio purposes will exceed that for radio applications.

During the greater part of 1945, all development and production facilities of the RCA tube department, in common with virtually all other facilities of the company, were devoted to supplying the needs of our Armed Forces.

When peace returned to the world, the electron-tube industry was one of those which found itself in the fortunate position of having no major reconversion problems requiring modification of facilities.

A substantial expansion of business in the transmitter field is foreseen, principally resulting from construction of new television and frequency-modulation transmitters, but the bulk of the increase in demand for power tubes is expected to come ultimately from applications in nonradio electronic equipment.

High-frequency heating equipment for industry, for example, will require many times the power tubes currently employed in the radio broadcast industry. One company alone in the last year has installed high-frequency heating equipment to a total of some 10,000 kilowatts capacity, whereas the total rated output power of all broadcast stations in the United States is only 3700 kilowatts.

(Continued on page 75A)

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY



Accurate LONG RANGE Navigation...anytime...in all weather

With Sperry Loran the navigator has at hand a quick and accurate means of determining a ship's position at any time, in all kinds of weather. This system involves the reception of accurately timed radio pulses from shore-based transmitting stations, usually 200 to 400 miles apart.

The *difference in time of arrival* of signals from a pair of transmitting stations is measured and the time difference is then used to determine, from special charts or tables, a line-of-position on the earth's surface. When two lines-of-position from two different pairs of Loran stations are

crossed, you have a "Loran fix." Fixes are obtainable at distances from shore stations up to 1400 miles at night, 700 miles in daytime.

In your consideration of Loran, note particularly that Sperry's equipment is easy to operate. A Time Difference Meter (see illustration above) greatly simplifies the operator's

work and prevents errors in readings.

Sperry Loran is backed by a worldwide service organization and meets the usual high standards of test and performance of all Sperry products. *Loran equipments in limited quantity are ready for immediate delivery.*

**The Time Difference Meter, giving position references directly, is a Sperry exclusive.*



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BALTIMORE

"Frequency Modulation and Control Symposium," by James Day, Radio Engineering Laboratories, J. E. Young, Radio Corporation of America, W. G. Broughton, General Electric Company, M. R. Briggs, Westinghouse Electric Corporation; February 26, 1946.

"Aspects of Color Television," by P. C. Goldmark, Columbia Broadcasting System; March 26, 1946.

BOSTON

"Radar Countermeasures," by R. A. Soderman, General Radio Company; March 22, 1946.

BUFFALO-NIAGARA

"Methods of Electronic Control," by W. D. Cockrell, General Electric Company; February 20, 1946.

"Microwave Generation and Utilization in Communication," by J. B. H. Kuper, Federal Telecommunications Laboratories; March 20, 1946.

CEDAR RAPIDS

"New Methods in the Air Navigation Program," by H. I. Metz, Civil Aeronautics Authority; March 20, 1946.

"Printed Electronic Circuits," by R. L. Wolff, Centralab Company; March 20, 1946.

CHICAGO

"Development and Trends in Radio Receiving Tubes," by L. G. Hector, National Union Radio Corporation; March 15, 1946.

"Industrial Applications of Electron Tubes," by E. E. Moyer, General Electric Company; March 15, 1946.

CINCINNATI

"Television Equipment for Guided Missiles," by C. J. Marshall, ATSC Wright Field; March 19, 1946.

CLEVELAND

"Magnetic Recording, Physical Aspects and Recent Developments," by Otto Koreni, Brush Development Company; March 28, 1946.

COLUMBUS

"Experiences of the State Highway Patrol With Frequency Modulation," by A. B. Shirk, State Highway Patrol Radio; February 8, 1946.

CONNECTICUT VALLEY

"CBS Color Television," by Paul Reidy, Columbia Broadcasting System; February 21, 1946.

"Offensive Use of Radar," by D. P. Tucker, United States Navy; March 14, 1946.

DAYTON

"Engineering Education Meets the Challenge," by W. L. Everitt, University of Illinois; March 5, 1946.

"My Impressions of Japan," by G. L. Haller, Aircraft Radio Laboratory; March 5, 1946.

(Continued on page 38A)

✓ low mass	✓ no springs no counterweights
✓ faithful tracking	✓ absorbs shocks
✓ higher output	✓ longer record life
✓ greater lateral needle point compliance	✓ clearer, fuller tone qualities
✓ 1½ oz. needle force	✓ lever-driven crystal

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metals
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Callite processes tube components by methods perfected after years of research and experience. Let us cooperate with you. We may be able to save you time and money. Callite Tungsten Corporation, 544 Thirty-ninth St., Union City, N. J. Branch Offices: Chicago, Cleveland.



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For FM and TV

NEW ANDREW COAXIAL CABLE WITH
51.5 OHMS IMPEDANCE!

Meets Rigid FM-TV Standards

A new coaxial cable, especially designed for FM and TV use, is now a reality at the Andrew Co. Scheduled for mid-June delivery to the first orders received, these new cables, in 4 sizes, introduce the following important engineering features:

1. Characteristic impedance of 51.5 ohms. (The regular Andrew cables for AM applications have a nominal impedance of 70 ohms.)
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3. Insulators are spaced 12 inches apart in the 3 large size cables, and 6 inches in the $\frac{7}{8}$ -inch cable.
4. Improved low loss insulation material is used, having a dielectric constant of 6.0 and a maximum loss factor of .004 at 100 mc.
5. Close tolerances have been established on conductor and insulator dimensions, in order to maintain a constant characteristic impedance.
6. Inner and outer conductors are made of copper having a minimum conductivity of 95% IACS at 25° centigrade.

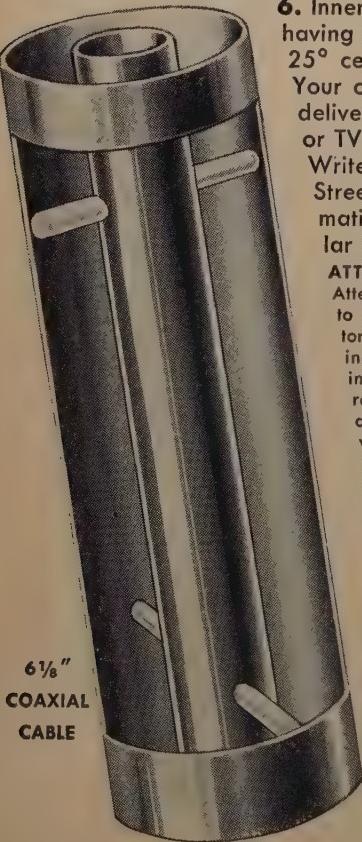
Your order now is the best assurance of early delivery on this new coaxial cable for your FM or TV installation.

Write or wire the Andrew Co., 363 East 75th Street, Chicago 19, Illinois, for complete information or engineering advice on your particular application.

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Attenuation is calculated to provide for conductor and insulator loss, including a 10% derating factor to allow for resistance of fittings and for deterioration with time.

- The new 51.5 ohm air insulated coaxial cable for FM and TV comes in 4 sizes, priced tentatively as follows: $\frac{7}{8}$ ", .42c per ft.; $1\frac{1}{8}$ ", .90c per ft.; $3\frac{1}{8}$ ", \$2.15 per ft.; $6\frac{1}{8}$ ", \$5.20 per ft. Andrew Co. also manufactures a complete line of accessories for coaxial cables.



(Continued from page 36A)

DETROIT

"The Design and Development of an Inter-modulation Test Set," by G. W. Archer, International Detrola Corp.; March 21, 1946.

MONTREAL

"Radio Broadcasting in Canada," by Augustin Frigon, Canadian Broadcasting Corporation; February 27, 1946.

"A Cylindrical Oscillograph," by R. P. Langlois, University of Montreal; March 13, 1946.

"A Compensated Cathode-Ray Tube Using a Nonlinear Time Base," by L. A. Dion, University of Montreal; March 13, 1946.

"Analysis of Multiplex Transmission Systems," by P. H. Lavallee, Laval University; March 13, 1946.

"Automatic Frequency Control for the Very Highs," by Bruce McCaffrey, Queens University; March 13, 1946.

"Radio Microwaves and Radar," by W. H. Doherty, Bell Telephone Laboratories; March 21, 1946.

OTTAWA

"Frequency-Shift Radio Teletype," by J. Mitchell, RCA Victor Company, Ltd.; January 17, 1946.

Demonstration of Captured German Army Equipment by Captain MacDonald, Lt. Cooke, and Sgt. Major Singer, Canadian Army; February 7, 1946.

"Canada's Short-Wave Stations," by R. C. Cahoon and Peder Aylen, Canadian Broadcasting Corporation; March 1, 1946.

"Microwave Antennas," by Keith MacKinnon, Consulting Engineer; March 21, 1946.

PHILADELPHIA

Part I—"Critical Comparison of Continuous Wave, Frequency Modulation, and Pulse Radar," by Irving Wolff, RCA Laboratories; March 7, 1946.

Part II—"Altimeter Developments," by Irving Wolff, RCA Laboratories; March 7, 1946.

PITTSBURGH

"Philco Philadelphia to Washington Television Relay Link," by F. J. Bingley, Philco Radio and Television Corporation; February 11, 1946.

PORLAND

"Loran System," by Earl Schoenfeld, RCA Laboratories; February 27, 1946.

"Some Aspects of Atomic Energy," by Manuel Holtzman, Manhattan Atomic Bomb Project; March 13, 1946.

ROCHESTER

"Future Significance of Wartime Electronic Developments," by D. G. Fink, Electronics Magazine; March 14, 1946.

(Continued on page 40A)

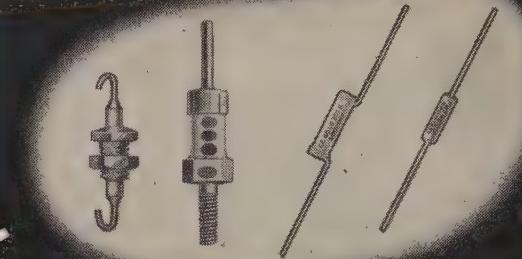
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IT'S
ERIE RESISTOR



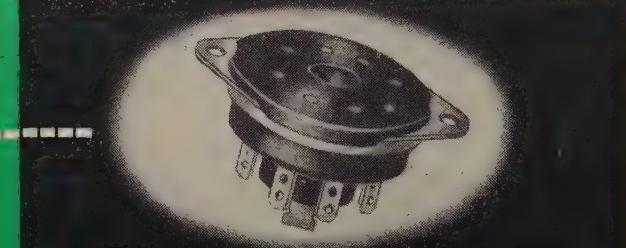
*Electronic Components
 and Products*

Due to the high operating frequencies of FM, many electrical and mechanical characteristics not ordinarily considered in condensers, become of paramount importance. The most important of these is low inductance, both in leads and in the basic construction of the condensers themselves.

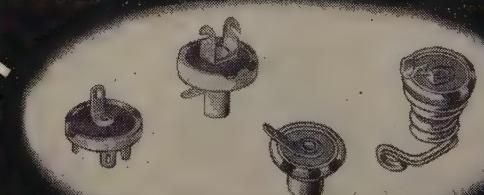
The condensers illustrated on this page fulfill this requirement through simplicity of design and low internal inductance. For by-pass applications, Erie Stand-Off Ceramicons and Erie Feed-Thru Ceramicons are most efficient for carrying off R.F. current to ground. Heavy terminals, with direct connection to ground, reduce external and internal inductance to a minimum. Available capacities, up to 1,000 MMF, are usually sufficient to efficiently by-pass frequencies of 80 MC or higher. Tubular Ceramicons, shown at the top right, have the same internal advantages as the Stand-Off and Feed-Thru type Ceramicons, because of their simplicity of construction, but are provided with regular pigtails necessary for many installations where



FEED-THRU, STAND-OFF, PIGTAIL CERAMICONS



CINCH-ERIE PLEXICON TUBE SOCKETS
 with built-in By-Pass Ceramicons



ERIE BUTTON MICA CONDENSERS

some moderate lead inductance can be tolerated.

The Cinch-Erie Plexicon Tube Socket, shown in the center photograph, with built-in by-pass Ceramicons, puts the condensers around the tube pins—where they belong. Leads are practically eliminated, and other components can be installed closer to the socket, further increasing efficiency. Any tube pin or groups of pins can be by-passed with condensers having up to 1,000 MMF capacity.

Erie Button Mica Condensers were designed specifically for high frequency work. Ribbon type leads, plus circular design, gives extremely short electrical path-to-ground through the entire area of the condenser. These compact units are available in a number of different mounting styles and in capacity ranges up to .006 mfd.

You can stake your reputation on these condensers for dependable use in tuned circuits, for by-pass applications, or as coupling condensers, in all FM applications. Write for complete details, giving desired operating characteristics.



Electronics Division

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How Many Slices in a Loaf of Bread?



It's unimportant unless there aren't enough to go around. When the loaf isn't large enough to feed everyone who asks for a slice, the problem becomes involved. The size of each slice takes on significance.

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Soon, we hope to be able to meet your constantly increasing demands. Meanwhile, there can be no change in the Stancor policy of quality. We know you wouldn't want it any other way.

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PRESIDENT

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SECTION MEETINGS

(Continued from page 38A)

ST. LOUIS

"Electronic Applications in Aircraft Testing," by I. A. Shepard, Shepard Engineering Company; February 28, 1946.

"Physics of Nuclear Energy," by K. K. Darrow, Bell Telephone Laboratories; March 18, 1946.

"Television. Its Mechanism and Promise," by W. L. Lawrence, RCA-Victor Division; March 28, 1946.

SAN DIEGO

"Pulse-Position-Modulation Radio-Communication Equipment," by J. H. Clark, Southern California Telephone Company; March 5, 1946.

SEATTLE

"Aircraft Instrument-Landing Systems," by V. L. Palmer, University of Washington; February 8, 1946.

"The Loran System of Long-range Navigation," by Earl Schoenfeld, RCA Laboratories; February 28, 1946.

TWIN CITIES

"A Three-Beam Oscilloscope for Recording at Frequencies Up to 10,000 Megacycles," by G. M. Lee, Central Research Laboratories; March 19, 1946.

WASHINGTON

"Short-Wave Direction Finding," by Henry Busignies, Federal Telecommunications Laboratories; November 12, 1945.

"VT or Radio Proximity Fuse," by Harry Diamond, National Bureau of Standards, and Harner Selvidge, Johns Hopkins University; November 19, 1945.

"Research," by Dr. Kettering, General Motors Company; November 20, 1945.

"Precipitation Static," by Ross Gunn, Joint Army-Navy Precipitation-Static Group; December 10, 1945.

"Microwaves," by W. C. White, General Electric Company; January 8, 1946.

"Very-High-Frequency Wave Propagation, Particularly in the 50-to-100-Megacycle Region," by E. W. Allen, Jr., Federal Communications Commission, and C. W. Carnehan, Zenith Radio Corporation; January 14, 1946.

"Radar Echoes From the Moon," by E. K. Stodola, Evans Signal Laboratories; February 11, 1946.

"The Maximum Range of A Radar Set," by A. C. Omberg, Bendix Aviation Corporation; February 27, 1946.

"Complimentary Diversity Reception on Microwaves," by T. J. Carroll, Office of the Chief Signal Officer; March 11, 1946.

WILLIAMSPORT

"Measurements at Microwave Frequencies," by F. J. Gaffney, Polytechnic Research and Development Company; April 3, 1946.

SUBSECTIONS

PRINCETON

"The Measurement of Thermal Radiation at Microwave Frequencies," by R. H. Dicke, Princeton University; March 13, 1946.

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Call him when you need Insulation assistance

A quick summons brings the IMC engineer to your side to give expert consideration and advice on all your most intricate and stubborn electrical insulation problems. He will serve you well . . .

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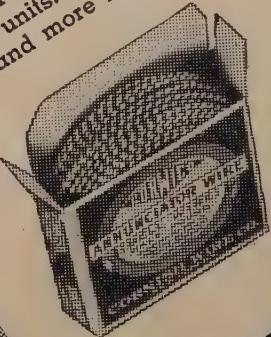
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Bliss, W. H., 235 Newton Ave., Riverhead,
N. Y.

Brady, F. B., 25 Arnold Pl., Dayton 7,
Ohio

Brunetti, C., National Bureau of Standards,
Washington 25, D. C.

Carnes, W. T., Jr., 2815 W. 68 St., Mission,
Kan.

Cole, R. I., Watson Laboratories, ATSC,
Red Bank, N. J.

Emurian, A. D., 617 W. Sedgwick St.,
Philadelphia 19, Pa.

Ferguson, J. C., 1005 W. Packard Ave.,
Fort Wayne 6, Ind.

Ferrier, D. T., 1737 Cambridge St., Cambridge,
Mass.

Fisher, B. A., Electrical Engineering Dept.,
U. S. Naval Academy, Annapolis,
Md.

Frink, F. W., 106 N. Grove St., East
Orange, N. J.

Gannaway, R. R., 411 S. Harvey, Oak
Park, Ill.

Greer, J. W., Code 930A, Electronics Div.,
Bureau of Ships, Navy Dept.,
Washington 25, D. C.

Hansell, G. E., 140 Moriches Rd., Riverhead,
N. Y.

Hucke, H. M., Radio Corporation of
America, Camden, N. J.

Hussey, L. W., 24 Pine Ave., Madison,
N. J.

Kinsell, W. L., 4506 Wilmette St., Fort
Wayne 5, Ind.

Knight, A. R., 1657 Hearthstone Dr.,
Dayton 10, Ohio

Koros, L., Echeverria 3368, Buenos Aires,
Argentina

Lowry, L. R., Rumson Rd., Little Silver,
N. J.

Magnuski, H., 2825 Logan Blvd., Chicago
47, Ill.

Maxwell, D. E., Columbia Broadcasting
System, Inc., General Engineering
Dept., 485 Madison Ave., New
York 22, N. Y.

Meahl, H. R., Room 461, Bldg. 5, General
Electric Co., Schenectady 3, N. Y.

Morlock, W. J., 3723 N. Denny St.,
Indianapolis, Ind.

Mullin, L. A., 25 Applied Science Bldg.,
Syracuse University, Syracuse 10,
N. Y.

Nottingham, W. B., Massachusetts Institute
of Technology, 77 Massachusetts Ave., Cambridge 39, Mass.

Reichle, W. E., Bell Telephone Laboratories,
180 Varick St., New York,
N. Y.

Rojas, F. R., 14 Sterling Pl., Malverne,
N. Y.

Sanders, E. R., 9407 Garwood St., Silver
Spring, Md.

Scott, E. D., 1103 Trenton Pl., S.E.,
Washington 20, D. C.

Taylor, J. H., 243 Linden Ave., Towson 4,
Md.

(Continued on page 44A)



You can Start!—Stop!—Reverse!—or
“Keep things moving!”

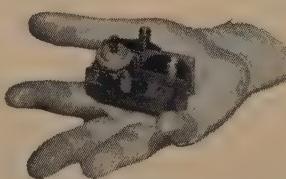
Alliance Power-pakt motors will do one or all! They'll multiply automatic operations, provide better control, and speed up performance.

Operating characteristics and power ratings are variable. For radio, electronic, electric and heating controls—for remote actuation, continuous and intermittent duty, there's probably an Alliance motor already "built to your order".

Here Are Just A Few Places:

Electronic and electric controls, time, pressure, temperature and humidity controls, remote actuation controls, radio tuning and turntable drives, coin operated dispensers, fans, valves, blowers, door openers, signals, motion displays, projectors and specialized uses.

ALLIANCE MOTORS are made with centerless ground precision shafts; large, self-aligning, graphite bronze oilless-type bearings; and with adequate mounting facilities to incorporate them in any device. Shaded pole induction type motors for A.C. voltage from 24 to 250, and frequencies of 40, 50 or 60 cycles have starting torques from one-half ounce-inches at 10 watts, to two ounce-inches at 36 watt input. Split phase resistor type, enclosed reversible control motors for intermittent duty, with or without integral gear reduction are made for 60 cycles, 24 or 117 volts. Typical weights run from less than 13 ounces to more than two and one-half pounds.



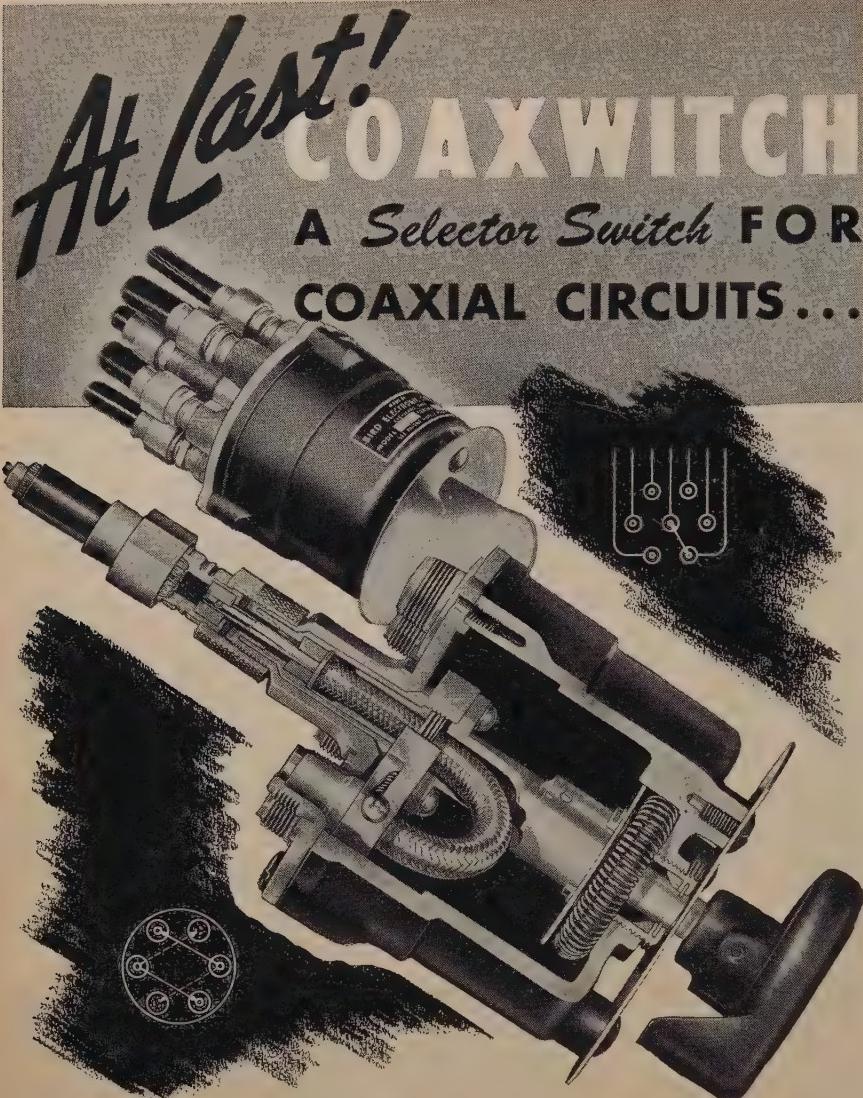
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Here's the switch you've been looking for. Now a simple and efficient means of switching coax lines is available in three models. Present Types handle 50-ohm coax at frequencies up to 4000 megacycles. Characteristic impedance is maintained thru all switch details.

Application: Selection of antennas, receivers, low power transmitters; Intra-equipment switching in coax links; with phase monitors in directionals; double-ended selection of insertion devices, filters, etc.

Model 74 handles single line with choice of six channels. Model 718 is similar to Model 74 but with 8-channels. Model 72-2 is a double-pole, double-throw type for switching two circuits simultaneously. Other versions of the novel switching action of the COAXWITCH and other impedance levels are under development. If you have a coax switching problem, we can help you. Data sheets are available. Write

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(Continued from page 42A)

- Tucker, D. P., 2707 Adams Mill Rd., N.W., Washington 9, D.C.
Upp, C. B., Naval Research Laboratory, Electronics Section, Washington 20, D.C.
Van Ryn, J. C., Woodstock, N.Y.
Watton, A., Jr., TSEPL-6, Propeller Laboratory, Hq. Air Technical Service Command, Wright Field, Dayton, Ohio
Webb, J. S., Electrical Engineering Dept., University of Minnesota, Minneapolis, Minn.

Admission to Senior Member

- Closson, L. E., Philco Corp., C and Tioga Sts., Philadelphia 34, Pa.
Colton, R. B., 927-15 St., N.W., Washington, D.C.
Dennis, J. L., 2 Parran Dr., Dayton 10, Ohio
Goddard, C. T., 1626 River St., Belmar, N.J.
Guarino, P. A., 3578 W. 130 St., Cleveland, Ohio
Hamlett, R. T., 339 Park Ave., Manhasset, L.I., N.Y.
Hessler, V. P., Electrical Engineering Dept., University of Kansas, Lawrence, Kan.
Hubbard, M. M., 15 Waldron Court, Marblehead, Mass.
Hunter, P. B., 136 Hillside Ave., Metuchen, N.J.
Knowlton, A. D., 9 Bedford Rd., Summit, N.J.
Lacy, R. E., 95 East River Rd., Rumson, N.J.
Lammers, E. S., Jr., Westinghouse Electric Corp., Box 4808, Atlanta, Ga.
Lewyt, A. M., 60 Broadway, Brooklyn, N.Y.
McMillan, E. B., 30 Avon St., Wakefield, Mass.
Plamondon, A. D., Jr., 6 N. Michigan Ave., Chicago 2, Ill.
Schrenk, M. H., 2618-32 St., S.E., Washington 20, D.C.
Thwaites, J. T., 111 Leinster Ave. S., Hamilton, Ont., Canada
Trotter, H., Jr., 357 Cobbs Hill Dr., Rochester 10, N.Y.

Transfer to Member

- Beers, Y., 8 Gorham St., Cambridge 38, Mass.
Belleville, L. M., RFD 14, Box 800, Portland 16, Ore.
Benner, H. J., 75 Riverview Ave., Longmeadow 6, Mass.
Bonadies, V. J., 28 Hillcrest Terrace, East Orange, N.J.
Bosman, E. H., 54-14-254 St., Little Neck, L.I., N.Y.
Cary, T. R., Jr., 43 Pleasant St., South Weymouth 90, Mass.
Curtis, C. T., 10 Agassiz St., Cambridge, Mass.
Denton, A. D., 52A High Rd., Bushey Heath, Herts, England
(Continued on page 46A)



MN-62A

THE NEW NA-1 AIRCRAFT NAVIGATIONAL SYSTEM

*Latest addition to the already famous
Bendix Radio Compass Line*

A new example of Bendix Radio Creative Engineering—The NA-1 System furnishes automatic visual bearings and simultaneous aural reception of cw, mcw or voice signals in the range 100-1750 kc. It also serves as a low frequency range receiver, or manual direction finder, and operates on a straight wire antenna or static reducing loop throughout its frequency range.

The MN-62A Radio Compass Receiver is designed for operation with r.f. transmission lines up to 30 feet in length, for flexibility in location of loop and sense antenna. All receiver and loop control circuits are included in a single case. The receiver operates from a primary power supply of 115 V., 400 cycles a.c. and 28 V.d.c.

The MN-60A Iron Core Loop—Small, streamlined, is ideal for highspeed craft. It increases payload of aircraft by reducing air-drag.

All functions of the NA-1 System are controlled with the type MN-63A Remote Control Unit, or with custom-built controls designed for specific overall systems and types of airplanes. Bendix Radio specializes in the design of such consolidated control assemblies.

Bearing indicators are available in several types and sizes for either a single or dual compass system.

All components of the NA-1 System are built to the same rigid specifications that have made Bendix the Greatest Name in Aircraft Radio. They bear CAA type certification for scheduled airline operation.

For full information, write to Sales Department

BENDIX RADIO DIVISION • BALTIMORE 4, MARYLAND



MN-60A



MN-63A



MN-37

BENDIX RADIO

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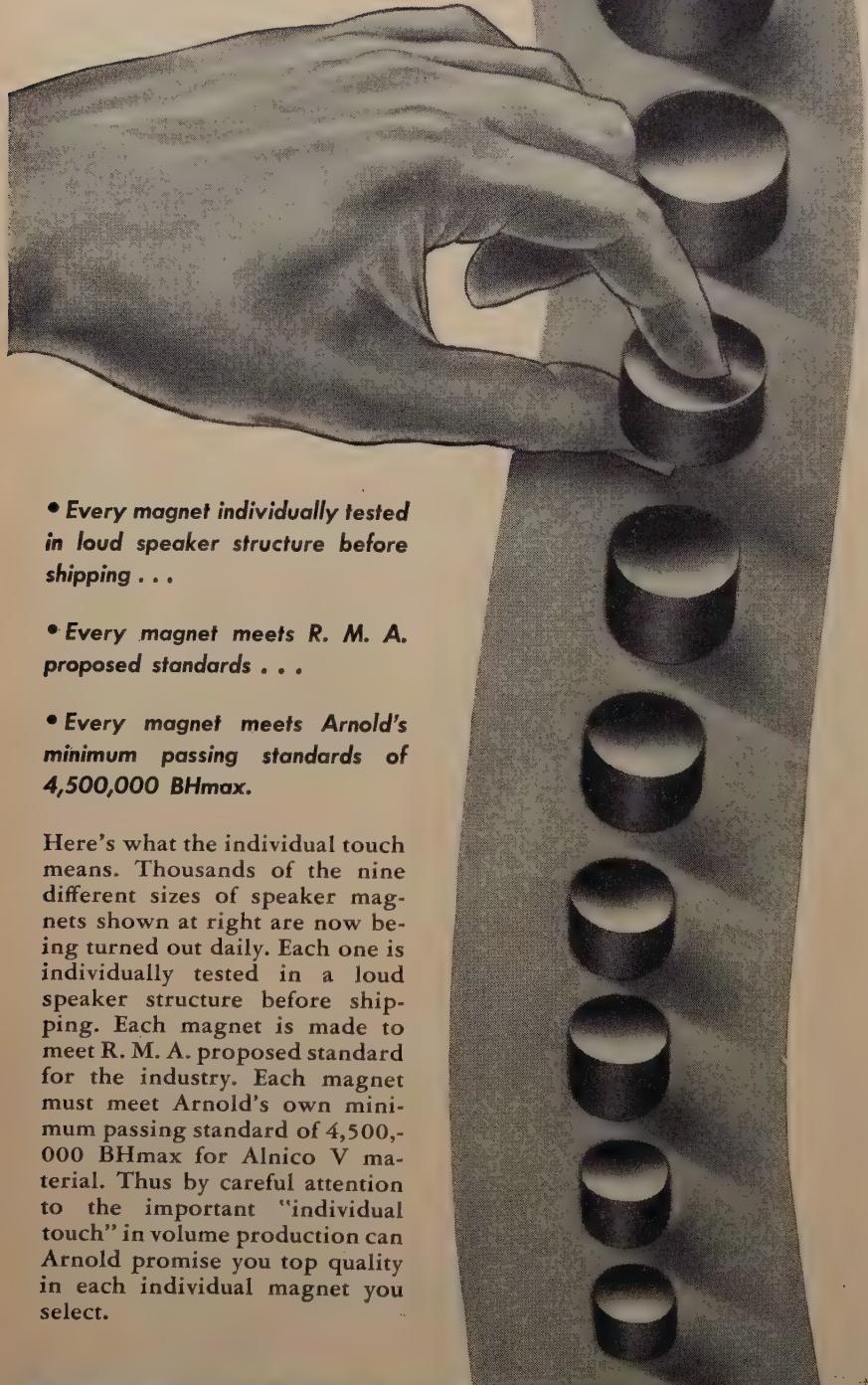
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Bendix
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STANDARD FOR THE AVIATION INDUSTRY

THE *Individual* TOUCH



- Every magnet individually tested in loud speaker structure before shipping . . .

- Every magnet meets R. M. A. proposed standards . . .

- Every magnet meets Arnold's minimum passing standards of 4,500,000 BH_{max}.

Here's what the individual touch means. Thousands of the nine different sizes of speaker magnets shown at right are now being turned out daily. Each one is individually tested in a loud speaker structure before shipping. Each magnet is made to meet R. M. A. proposed standard for the industry. Each magnet must meet Arnold's own minimum passing standard of 4,500,000 BH_{max} for Alnico V material. Thus by careful attention to the important "individual touch" in volume production can Arnold promise you top quality in each individual magnet you select.

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(Continued on page 52A)

KAAR *INSTANT HEATING* MOBILE FM

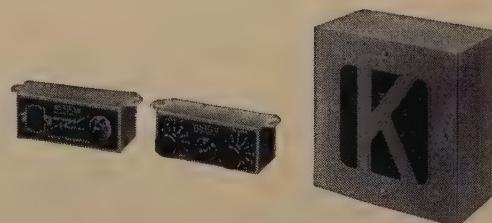


Now available! An FM Radiotelephone with a truly NATURAL voice quality!

New KAAR FM radiotelephones offer an improvement in tone quality which is surprising to anyone who has had previous experience with mobile FM equipment. The over-all audio frequency response through the KAAR transmitter and receiver is actually within plus or minus 5 decibels from 200 to 3500 cycles! (See graph below.) This results in vastly better voice quality, and greatly improved intelligibility. In fact, there is appreciable improvement even when the FM-39X receiver or one of the KAAR FM transmitters is employed in a composite installation.

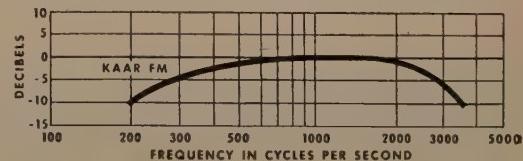
KAAR FM transmitters are equipped with instant-heating tubes, thus making it practical to operate these 50 and 100 watt units from the standard 6 volt ignition battery without changing the generator. Inasmuch as standby current is zero, in typical emergency service the KAAR FM-50X (50 watts) uses only 4% of the battery current required for conventional 30 watt transmitters. Battery drain for the KAAR FM-100 X (100 watts) is comparably low.

For full information on new KAAR FM radiotelephones, write today for Bulletin No. 24A-46.



KAAR LOUD SPEAKER, remote controls for transmitter and receiver (illustrated above) and the famous Type 4-C push-to-talk microphone are among the accessories furnished with the equipment.

IMPROVED OVER-ALL FREQUENCY RESPONSE THROUGH KAAR FM TRANSMITTER AND RECEIVER



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An Announcement

To Those Who Require

The Best

THIS advertisement is addressed to the manufacturers of electronic equipment whose product demands the best in component parts—who will want the best in transformers, if “the best” is offered at a price that will fit the cost specifications of their finished product.

By adapting to peace-time use the major features of the Hermetically-Sealed transformer construction that won war-time leadership, Chicago Transformer is prepared to provide the best in transformers to those who require them. Fully developed basic mounting parts, when utilized on a mass production basis, will provide the element of economy in manufacture.



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(Continued from page 54A)

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1. Essentially flat face
2. 7.5 – 10 KV anode supply
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Ideal for the Accurate measurement of AC voltages in the Audio, Supersonic, Carrier Current and Television ranges.

Use of Logarithmic voltage scale assures uniform accuracy of reading over whole scale while permitting range switching in decade steps.

Each Voltmeter equipped with an output jack so that the instruments can be used as a high-gain stable amplifier.

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RANGE—.001 to 100 volts.

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ACCURACY—2% at any point on scale.

AC OPERATION—110-120 volts.

MODEL 304

RANGE—.001 to 100 volts.

FREQUENCY—30 c.p.s. to 5.5 megacycles.

ACCURACY—0.5 DB.

AC OPERATION—110-120 volts.

MODEL 302

RANGE—.001 to 100 volts

FREQUENCY—5 to 150,000 cycles.

ACCURACY—2% at any point on scale.

DC OPERATION—self-contained batteries.

Send for Bulletin for further description

Model 302
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OPERATED



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(Continued on page 56A)



Collins 26W-1 Limiting Amplifier

Collins Speech Equipment

provides better program transmission and stronger signals

THE COLLINS 26W-1 audio limiting amplifier is a product of the most advanced standards of broadcast engineering. It effectively raises the modulation level, yet prevents overmodulation of the r-f carrier. The resulting stronger signal assists materially in station area coverage.

Developed for high fidelity AM and FM applications, the 26W-1 has a frequency response flat from 30-15,000 cps, with a variation of less than 1.0 db. The compression ratio above the verge of compression is 20/1 in db. Harmonic and tone distortion are not more than 1.5% at any frequency, any setting of the input and output levels, and with any amount of compression up to 15 db. Hum and noise are 70 db below the operating level. Output range is -4 to +26 dbm.

Complete metering provides measuring facilities for individual tube currents, plate volt-

age, compression level, and output level. Inside-out chassis construction gives immediate access to all wiring and circuit components upon removal of the slip-on dust cover. Operate and release times are independently adjustable.

Dimensions, for standard rack mounting, 19" w, 14" h, 9" d. Weight, 45 pounds. Available in metallic gray or black wrinkle.

Collins speech equipment is thoroughly engineered for highest performance. Reliable in operation, accessible in maintenance, each unit meets rigid inspection and tests before it is approved for delivery. For your requirements, write today to the Collins Radio Company, Cedar Rapids, Iowa; 11 West 42nd Street, New York 18, N. Y.

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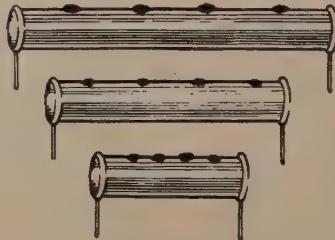
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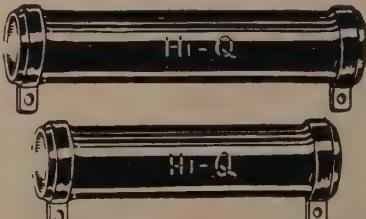
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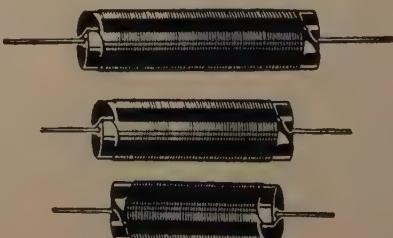
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Hi-Q Ceramic Capacitors are of titanium dioxide (for temperature compensating types) and are tested for physical dimensions, temperature co-efficient, power factor and dielectric strength. CI type with axial leads; CN type with parallel leads.



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A MULTI-PURPOSE AMPLIFIER of Broadcast Quality

Worthy of an
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Langevin 114-A Amplifier in 204-A Cabinet

LHE Langevin 114-A Amplifier is primarily a monitor amplifier. It is used in offices, audition and control rooms of radio stations and recording studios, and also fits the needs of wired music installations and other industrial uses wherever an amplifier for a single or dual speaker installation is required.

This amplifier operates on 110-120 volts AC or DC. It can be rack mounted or used in its own metal cabinet, Type 204-A; it has a frequency response of 30 to 15,000 cycles and delivers 3 watts of audio power at less than 2% RSS total harmonic distortion at 400 cycle single frequency. At 4 watts output the distortion is less than 5%.

ELECTRICAL CHARACTERISTICS

GAIN—Approximately 61 db high gain and 43 db when bridging a 600 ohm source. **OPERATES FROM** 0-1000 ohms using nominal 600 ohm input, 0-25,000 ohms using nominal 25,000 ohm input, with maximum gain depending upon impedance of bridged source. **OPERATES INTO**—Nominal load impedance of 4 ohms. Working range 2 to 8 ohms. **OUTPUT POWER**—Approximately 4 watts with less than 5%, and 3 watts with less than 2% RSS total harmonic distortion at 400 cycles single frequency into nominal 4 ohm load. **OUTPUT NOISE** 42 db below +35 VU (7 db below .001 watt) or better.

FREQUENCY CHARACTERISTIC—Production run ± 1.5 db over the range of 30-15,000 cycles. **POWER REQUIREMENT**—110-120 volts, 25-1000 cycles AC, or 110-120 volts DC. Amplifier draws 70 watts at 120 volts. **SIZE**—Maximum length 10 $\frac{1}{4}$ ", depth 6 $\frac{1}{2}$ ", height 6 $\frac{3}{4}$ ".

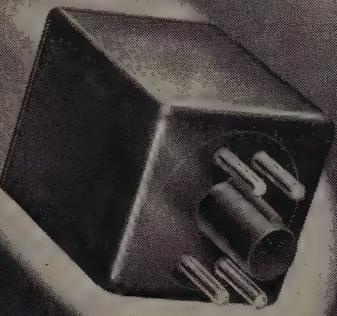
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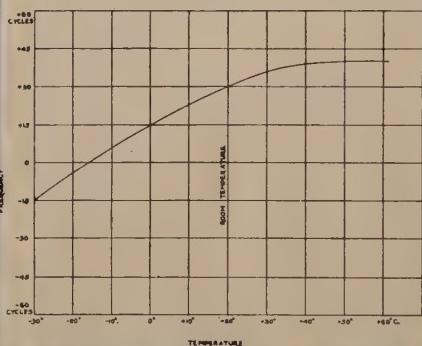


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Especially suitable for applications for close frequency tolerance . . . VHF services — police, aircraft, railway communications, etc. . . . works on 6.3v at 1 amp. . . . temp control within $\pm 3^\circ\text{C}$ operates at 60°C frequency control of $\pm .005\%$. . . frequency range 3MC to 14MC . . . fits octal socket . . .

TYPICAL C.R.L.—30 FREQUENCY TEMPERATURE CURVE



STANDARD SIGNAL GENERATOR Model 80

SPECIFICATIONS:

CARRIER FREQUENCY RANGE: 2 to 400 megacycles.

OUTPUT: 0.1 to 100,000 microvolts. 50 ohms output impedance.

MODULATION: AM 0 to 30% at 400 or 1000 cycles internal.
Jack for external audio modulation.

Video modulation jack for connection of external pulse generator.

POWER SUPPLY: 117 volts, 50-60 cycles.

DIMENSIONS: Width 19", Height 10 1/4", Depth 9 1/2".

WEIGHT: Approximately 35 lbs. PRICE—\$465.00 f.o.b. Boonton.

Suitable connection cables and matching pads can be supplied on order.



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(Continued on page 60A)

MEASUREMENTS CORPORATION
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SWING OUT WITH TURNER

COLORTONE *Micraphones*

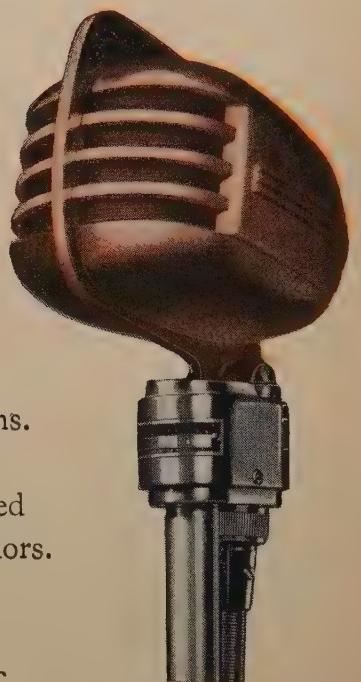
Turner pioneers again! *Colortones* are here
to bring distinctive beauty to microphone applications.

Especially created for bands, television studios,
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plastic microphones come in a range of gem-like colors.

Their lustrous, streamlined beauty will blend,
harmonize or contrast with any setting.

And new inside too! Improved crystal and dynamic
circuits result in smoother, more accurate reproduction.

Write for complete specifications and information
on *Colortone* colors now available.



Designed by
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DOUBLE END

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C. T. C. Turret Terminal Lugs have two soldering spaces. Lugs heat quickly, make wiring firm and neat. Made to fit $\frac{1}{8}$ ", $\frac{1}{16}$ ", $\frac{3}{32}$ ", $\frac{1}{8}$ ", $\frac{3}{16}$ " and $\frac{1}{4}$ " terminal board thicknesses. Also available with single soldering space and in Midget size.

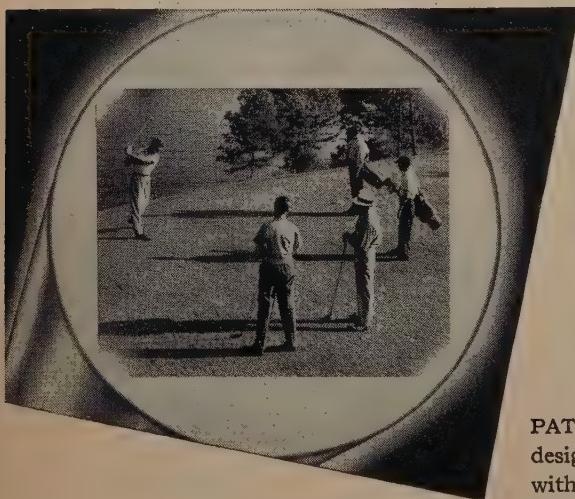
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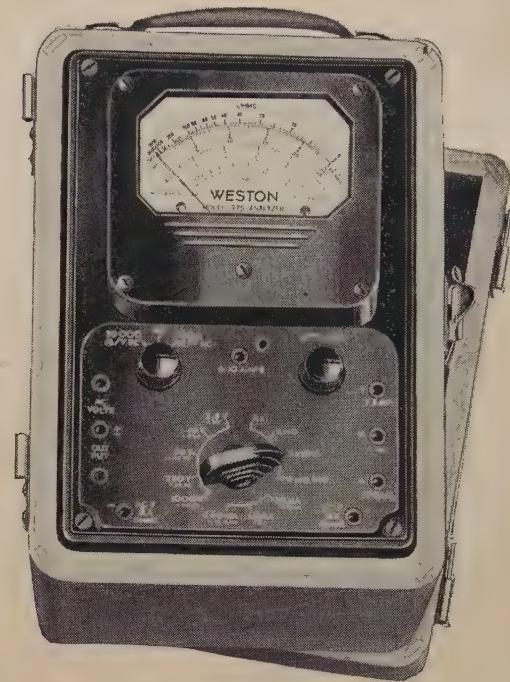


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- Julien, V. O., 212 N. "E." St., Marion, Ind.
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- Kaszerman, P., 566 Beck St., New York 55, N. Y.
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- Krupen, P., 1211 Raum St., N.E., Washington 2, D. C.
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- Litvenko, W., 16 Dow St., New Haven 10, Conn.
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- Murphy, E. J., 1 Conrad Court, Newport, R. I.
- Muse, D. W., Box 382, 215 McCoy St., Martinsville, Va.
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- Neal, N. A., WBOE, Board of Education, Cleveland 14, Ohio
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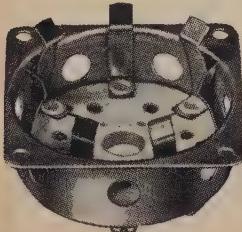
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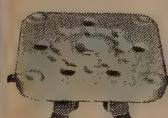
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 Possner, J. B., 3804 Grayburn Ave., Los Angeles 43, Calif.
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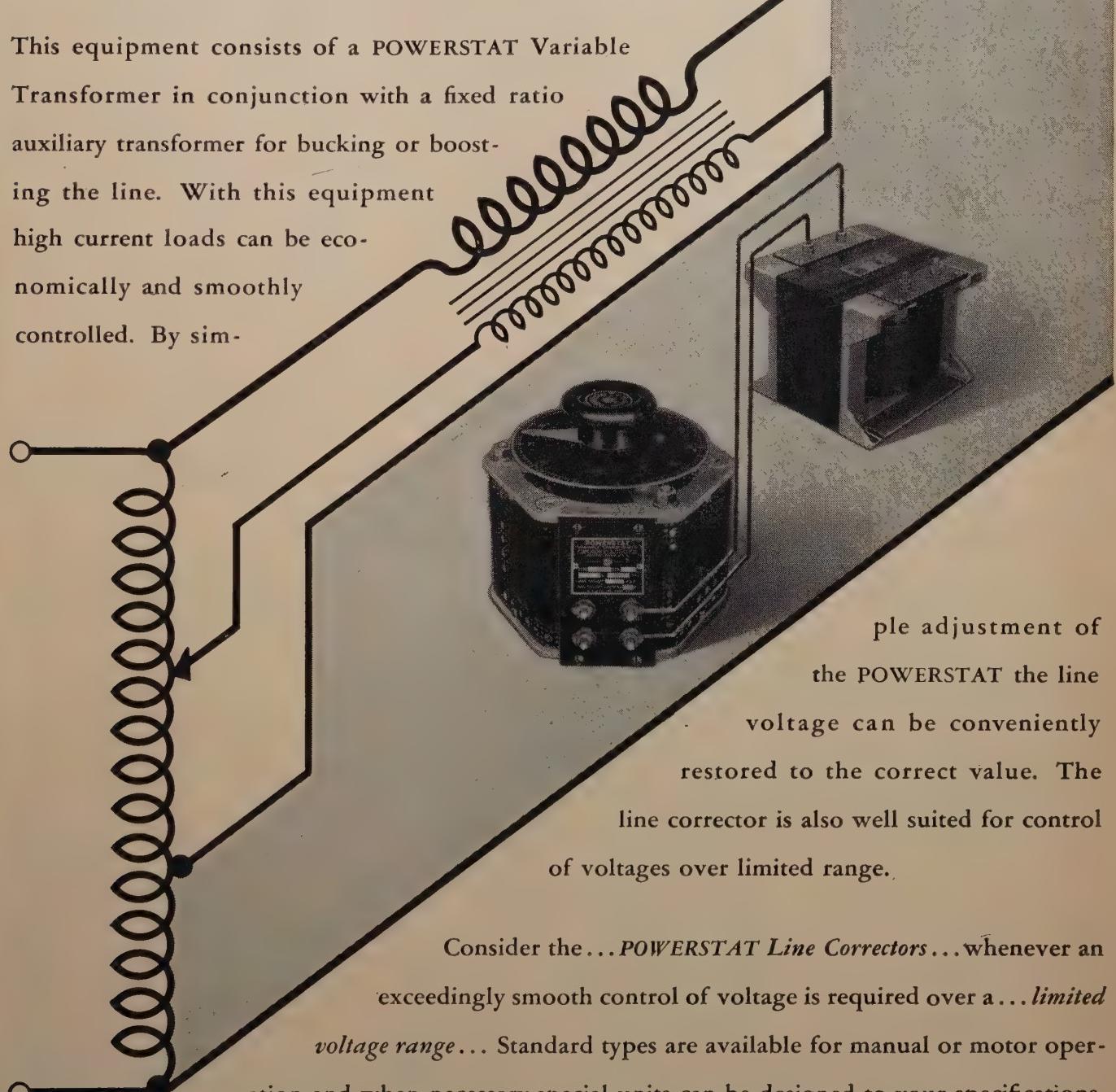
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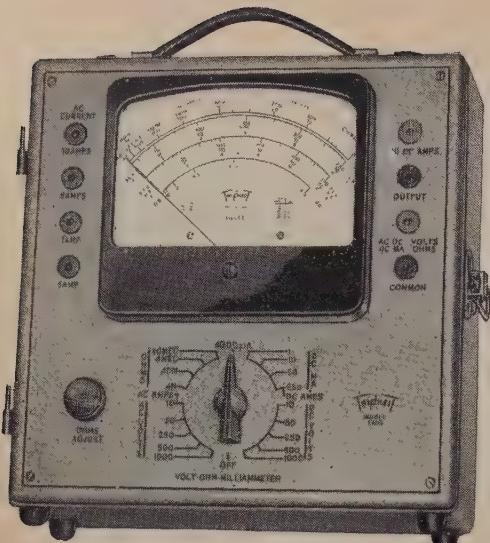
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67A



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Wells, C. H., Ordnance Research Laboratory, State College, Pa.

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Westcott, H. H., 938 Mercer St., Gloucester, N. J.

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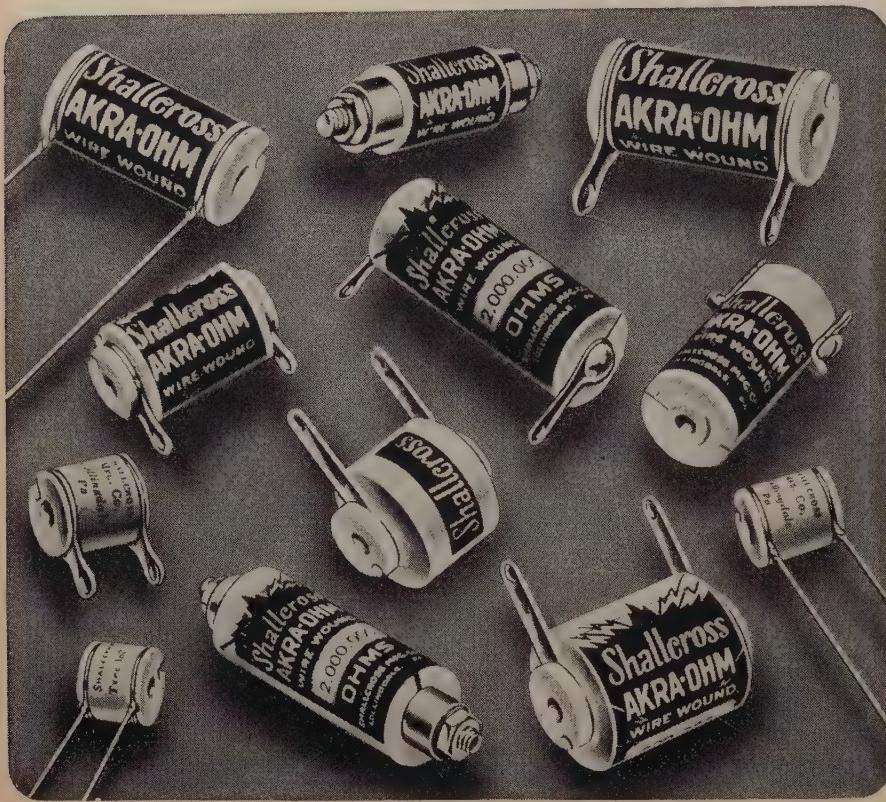
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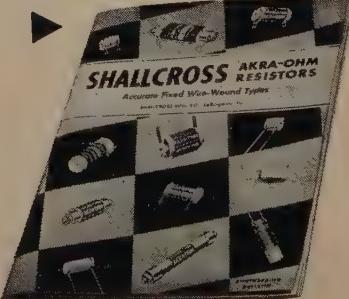
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"General Properties of Cavity Resonators," by W. A. Edson, Georgia Institute of Technology; January 18, 1946.

Election of Officers; January 18, 1946.

"Reports on Frequency-Modulation Transmitters, Television, Studio Audio Equipment, Quartz Crystals," by G. A. Rosselot, M. A. Honnell, R. A. Holbrook, and Ben Akerman; February 15, 1946.

BOSTON

"Radar Indicators," by L. J. Haworth Radiation Laboratory, Massachusetts Institute of Technology; February 8, 1946.

"Receivers for Microwave Radar," by S. N. Van Voorhis, Radiation Laboratory, Massachusetts Institute of Technology; February 15, 1946.

"The SCR-584, An Antiaircraft Radar Set," by I. A. Getting, Radiation Laboratory, Massachusetts Institute of Technology; March 1, 1946.

CEDAR RAPIDS

"High Frequency As Applied to Industrial Processing," by B. E. Rector, Westinghouse Electric Corporation; January 17, 1946.

"The Electroacoustics of Audition," by S. N. Reger, State University of Iowa; February 20, 1946.

"The Microwave Spectrum Analyzer," by Arthur Wulfsberg, Collins Radio Company; February 20, 1946.

CHICAGO

Engineering Conference and Annual Banquet; February 9, 1946.

"Development of the Phasitron," by Robert Adler, Zenith Radio Corporation; February 15, 1946.

"Field Intensities Beyond Line of Sight at 45.5 and 91 Megacycles," by C. W. Carnahan, Zenith Radio Corporation; February 15, 1946.

CINCINNATI

"Science Shapes the Future," by A. H. Compton, Washington University; March 1, 1946.

CLEVELAND

"Discussion, with slides, of various types of jet engines, and gas turbines," by A. Kindig, NACA, Cleveland Airport; February 20, 1946.

"Electronic Instruments and the Measurement of Radiation," by J. A. Victoreen, Victoreen Instrument Company; February 28, 1946.

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The WL 624 employs a control-grid structure of very large area which radiates directly through the glass envelope rather than into the other metal parts—an important feature for a shield-grid tube.

The tube is designed for the rough service encountered in many industrial applications and is equipped with a rugged industrial base.

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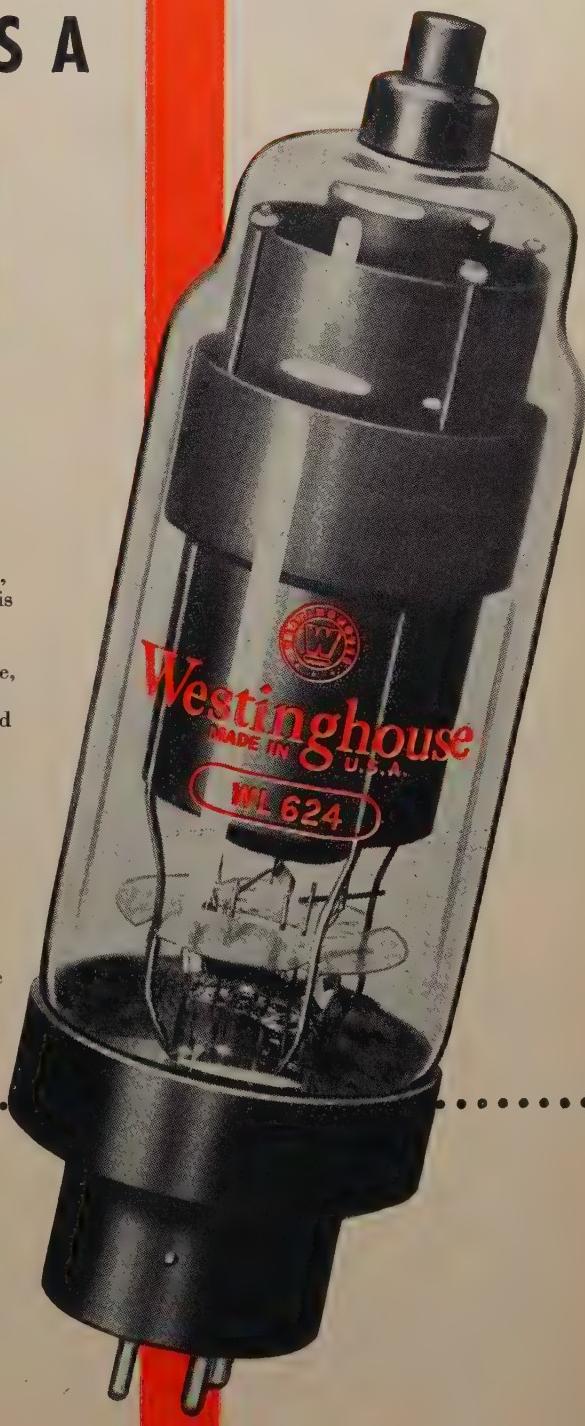
General Characteristics

Air cooled tetrode

Heater voltage	5.0 volts
Heater current	10.0 amperes
Cathode heating time	5 minutes
Tube voltage drop	15 volts
Control characteristics	negative

Maximum Ratings Up to 150 Cycles

Anode voltage, peak forward	2500 volts
Anode voltage, peak inverse	2500 volts
Anode current, average	6.4 amps.
Anode current, peak	77 amps.
Anode current, surge, for design only	770 amps.
Averaging time, anode and grid currents	15 seconds
Temp. range, condensed mercury	+ 40°C to + 80°C



Westinghouse

Electronic Tubes at Work



(Continued from page 36A)

DALLAS-FT. WORTH

"Frequency Measuring Apparatus Used by the Federal Communications Commission and Its Predecessors," by N. A. Hallenstein, Federal Communications Commission; February 19, 1946.

DAYTON

"Application of Radar to Aircraft," by J. E. Keto, F. L. Holloway, P. E. Koenig, I. Paganelli, L. B. Hallman, Jr., and R. D. Hultgren, Radar Laboratory, Wright Field; February 14, 1946.

DETROIT

"Engine Analysis by Electronics," by J. W. Head, Industrial Electronics, Inc.; February 15, 1946.

EMPIORIUM

"Recording on Magnetic Wire," by L. C. Holmes, Stromberg-Carlson Company; February 7, 1946.

LONDON

"Television," by F. S. Jackson, Radar and Communication School; January 18, 1946.

"The Electron Microscope," by E. F. Burton, University of Toronto; February 1, 1946.

LOS ANGELES

"Measurements in Frequency-Modulation Description of the New Phasitron," by Cameron Pierce, General Electric Company; January 18, 1946.

"Ground-Control-Approach Radar System," by William Lindsay, Gilfillan Brothers, Inc.; February 12, 1946.

MILWAUKEE

"VT Radio Proximity Fuse," by Cleo Brunetti, National Bureau of Standards, John M. Pearce, Johns Hopkins University, and A. S. Khouri, Globe Union Manufacturing Company; February 8, 1946.

MONTRÉAL

"Design Principles and History of Radar in Canada," by F. H. Sanders, National Research Council of Canada; January 16, 1946.

PHILADELPHIA

"The Heritage of Radar," by L. N. Ridenour, Radiation Laboratory, Massachusetts Institute of Technology; February 6, 1946.

PORRTLAND

"Radar and Its Component Parts," by Howard Vollum, Physicist; January 23, 1946.

"Radar Counter Measures," by E. A. Younker, Oregon State College; January 30, 1946.

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ROCHESTER

"Railroad Radio," by W. D. Hailes, General Railway Signal Company; February 21, 1946.

ST. LOUIS

"Coaxial Cable and Associated Carrier Equipment," by H. P. Lawther, Southwestern Bell Telephone Company; January 31, 1946.

SAN DIEGO

"Cathode-Follower Circuits," by D. C. Kalbfell, Physicist, University of California Division of War Research; February 5, 1946.

SAN FRANCISCO

"The Butterfly Circuit," by M. P. Klein, Universal Research Laboratories; January 30, 1946.

SEATTLE

"Frequency-Modulation Equipment," by W. U. Dent, Westinghouse Electric Corporation; January 16, 1946.

TORONTO

"Electronic Heating in Industry," by T. J. Thwaites, Canadian Westinghouse Electric Corporation; December 10, 1945.

"Radar, History and Fundamental Design Considerations," by F. Sanders, National Research Council Ottawa; January 14, 1946.

"Radar-Antenna Developments," by C. J. Bridgland, Research Enterprises, Ltd.; January 14, 1946.

"Circuits for the Measurements of Range," by J. D. Bain, Research Enterprises, Ltd.; January 14, 1946.

"German Radio-and-Communications Developments," by C. G. Lloyd, Canadian General Electric Company; February 4, 1946.

TWIN CITIES

"The Radio Proximity Fuse," by Cleo Brunetti, National Bureau of Standards; February 11, 1946.

WILLIAMSPORT

"High-Quality Recording on Magnetic Wire," by L. C. Holmes, Stromberg-Carlson Company; February 6, 1946.

"Some Broad Aspects of Specialization," by E. F. Carter, Sylvania Electric Products, Inc.; March 6, 1946.

Election of Officers; March 6, 1946.

SUBSECTIONS

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"The Heritage of Radar," by L. N. Ridenour, Radiation Laboratory, Massachusetts Institute of Technology; February 6, 1946.

MINIATURE POWER PLANT

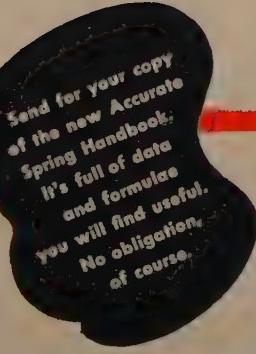
when it fails . . . your product fails

If, in your product there's a compact little power plant—commonly called a spring—you depend on that spring to deliver mechanical power as planned. Its function may be active or passive, but it *must* perform when called upon. If it doesn't, the *product* is blamed, *not* the spring.

Insure your product's good reputation with springs from Accurate . . . where everything possible is done to

give you springs you can depend upon. Our experienced spring engineers will help you be sure you have planned the right spring for the job... our skilled craftsmen and modern machinery assure you of fine workmanship . . . and, careful testing through critical stages of manufacture will give you springs that you can rely on to function well and long. Call us. We'd like to work with you.

*Accurate—
for springs
that won't
let your
product down*



SPRINGS
WIREFORMS
STAMPINGS

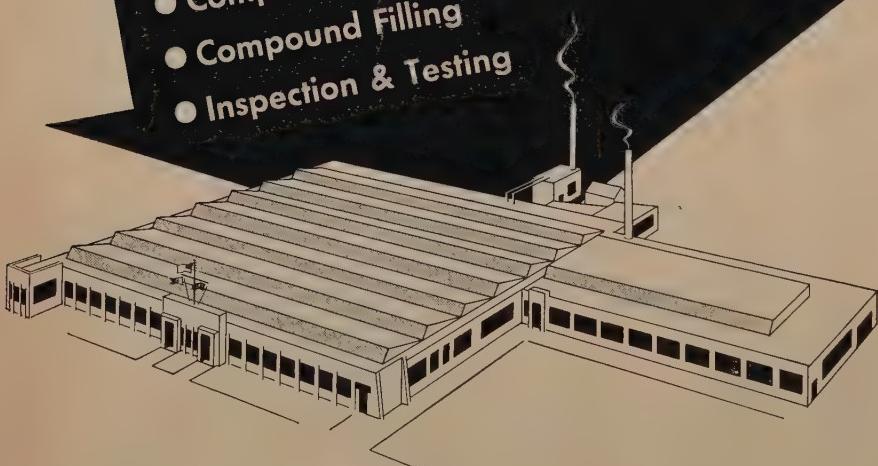
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Springs*

ACCURATE SPRING MANUFACTURING CO.

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Complete Facilities-

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- Complete Assembly
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*devoted to
One Primary Purpose*

**— the manufacture
of transformers to fit the
specialized requirements
of the Electronic Industry**



The following transfers and admissions were approved on March 6, 1946:

Transfer to Senior Member

- Cairnes, W. E., 8616 S. Wolcott Ave., Chicago 20, Ill.
 Fubini, E. G., 88 Central Park West, New York, N. Y.
 Goddard, D. R., Radio Corporation of America, Riverhead, L. I., N. Y.
 Hok, C. G. M., 10 Forest St., Cambridge 40, Mass.
 Isberg, R. A., 28 Curtis Pl., Lynbrook, L. I., N. Y.
 Libby, L. L., 10 Summit St., East Orange, N. J.
 Mackay, F. S., 788 Eglinton Ave. W., Toronto 10, Ont., Canada
 Nicholas, E. A. Farnsworth Television and Radio Corp., Fort Wayne 1, Ind.
 Pacholke, F., 10611 S. Bell Ave., Chicago 43, Ill.
 Pan, W. Y., 5 Clinton Ave., Merchantville, N. J.
 Peterson, A. P. G., General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
 Sharp, J. W., 6001 Dickens Ave., Chicago 39, Ill.
 Stuhrman, A. P., Wilcox Electric Co., 1400 Chestnut St., Kansas City 1, Mo.
 Tellman, H. A., 4641—30 Rd., Fairlington, Va.
 Wahlgren, W. W., 6021 College Ave., Oakland 11, Calif.
 Wickizer, G. S., 131 Brook St., Riverhead, L. I., N. Y.

Admission to Senior Member

- Begun, S. J., 3405 Perkins Ave., Cleveland 14, Ohio
 Blasi, E. A., 154 Park Dr., Dayton 10, Ohio
 Clark, A. B., Bell Telephone Laboratories, 463 West St., New York 14, N. Y.
 Friedlaender, E. R., 52 Mauldeth Rd., Manchester 20, England
 Leedy, H. A., Armour Research Foundation, 35 W. 33 St., Chicago 16, Ill.
 Martin, W. H., Bell Telephone Laboratories, 463 West St., New York 14, N. Y.
 Mason, W., 60 Broad St., New York 4, N. Y.
 Rahmel, H. A., A. C. Nielsen Co., 2101 Howard St., Chicago 45, Ill.
 Smith, F. B., 1527 Mars Ave., Lakewood, Ohio
 Sollie, S. A., Graybar Bldg., New York, N. Y.
 Van Deusen, G. L., 4000 Cathedral Ave., N. W., Washington 16, D. C.
 White, W. T., 1640 Aladdin Ave., New Hyde Park, N. Y.

(Continued on page 44A)



CHICAGO TRANSFORMER

DIVISION OF ESSEX WIRE CORPORATION

3501 ADDISON STREET • CHICAGO, IL

Announcing **STACKPOLE** SINTERED **ALNICO II**

Real economy for small magnet sizes and odd shapes
Better uniformity characteristics
Greater mechanical strength

Stackpole sintered Alnico II offers magnetic properties equal to those of the cast product—and with notable advantages in the production of weights up to two ounces either in standard or in odd shapes. Licensed under G. E. patents, Stackpole sintered Alnico II brings you all the features of a well-known product and the engineering experience of a firm which, since its inception, has specialized in the production of electrical components molded from powders.



STACKPOLE CARBON COMPANY, ST. MARYS, PA.

BRUSHES and CONTACTS (all carbon, graphite, metal and composition types)
IRON CORES • POWDER METALLURGY COMPONENTS HAVING SPECIAL
ELECTRICAL PROPERTIES • RARE METAL CONTACTS • RHEOSTAT PLATES
AND DISCS • CARBON PIPE • ANODES AND ELECTRODES, ETC., ETC.

ALWAYS ROOM FOR ONE MORE



(Continued from page 42A)

Transfer to Member

- Adams, B. N., 215-10—111 Rd., Queens Village 9, L. I., N. Y.
 Adams, K., General Radio Co., 920 S. Michigan Ave., Chicago 5, Ill.
 Baerwald, H. G., 3405 Perkins Ave., Cleveland 14, Ohio
 Beizer, H. H., 1955 La Mothe, Detroit 6, Mich.
 Bonham, W. E., 31 Hubbard Ave., Red Bank, N. J.
 Bullen, C. V., 415 N. First St., Rockford, Ill.
 Cartier, W. O., 45 Moore Ave., Toronto, Ont., Canada
 Chapman, S., Physics Dept., Stanford University, Calif.
 Crump, E. E., 10 Summit Ave., East Orange, N. J.
 Doersam, P. D., 835 Brunswick Rd., Essex, Baltimore 21, Md.
 Ewing, E. G., BM/EGE, London W.C. 1, England
 Freedman, M. M., 144-34—72 Dr., Kew Gardens Hills, L. I., N. Y.
 Hansen, B. P., 738 W. Broadway, Council Bluffs, Iowa
 Holliday, F. S., 411 Federal Annex, Atlanta, Ga.
 Hopper, A. L., 85 Spring Valley Ave., River Edge, N. J.
 Inglis, A. F., 623 Woodland Ave., Petoskey, Mich.
 Killgore, H. S., Box 1120, Washington, D. C.
 Maury, M. A., 232 Jackson St., Hempstead, L. I., N. Y.
 McCann, D. J., 1306 Hinman Ave., Evanston, Ill.
 Patterson, T. C., 22 Dryburn Rd., Durham Moor, N. Durham, England
 Ronzheimer, S. P., 5025 N. Rockwell St., Chicago 10, Ill.
 Sanders, E. W., Box 152, Andalusia, Pa.
 Schonert, K. E., Knollwood Apts, Stamford, Conn.
 Skipper, L. C., 98 Colony Dr., Baldwin, L. I., N. Y.
 Soria, R. M., 3300 S. Federal St., Chicago 16, Ill.
 Springer, P. W., 1115 Linden Ave., Dayton 10, Ohio
 Stavis, G., 474 Third Ave., New York 16, N. Y.
 Von Alven, W. H., 1012 Euclid Ave., Boise, Idaho
 Walker, R. E., Civil Aeronautics Administration, Box 440, Reference 99, Anchorage, Alaska
 Weber, J., Code 920, Bureau of Ships, Navy Dept., Washington 25, D. C.
 Webster, G. E., Collins Radio Co., Cedar Rapids, Iowa
 Weiss, E., 2901 S St., S.E., Washington 20, D. C.
 Weiss, M. M., 2032 Creston Ave., New York 53, N. Y.
 Yamins, H. G., Engineering Branch, Camp Evans Signal Laboratory, Belmar, N. J.

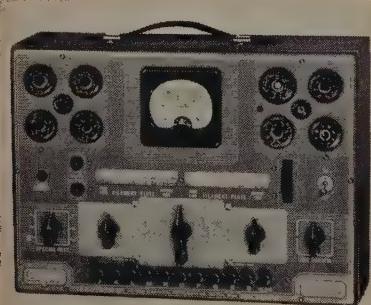
(Continued on page 46A)



The unusually flexible switching system in your Jackson Dynamic Tube Tester is designed to check new tubes for receivers as they come out. New roll charts supplied when necessary. Spare socket positions are also provided.

MODEL 636 DYNAMIC TUBE TESTER

with built-in rotary tube chart



"Dynamic" Method of Test—Makes a better test on every tube. The "Dynamic" method is more accurate, frequently finding poor tubes which might pass for good in ordinary testers.

New High-Voltage Power Supply is a feature of this tester. By testing tubes

at higher plate voltages (over 200 V. for some types), more accurate results are obtained.

Tests All Tubes—ALL of the popular receiving types and television amplifiers, including BAMTAMS—LOCTALS—SINGLE ENDED—HIGH VOLTAGE FILAMENT TYPES AND MINIATURES. Provision for many more. The tester is protected against obsolescence in every possible feature.

Roll Chart tube index—simplifies correct settings.

Full Range Filament Selections—From $\frac{3}{4}$ V. to 115 V. Selector marked directly in volts. This feature eliminates guess work and helps operator to avoid mistakes.

Most Improved Type of Switching System—Spare circuits and switch positions provided for future use. Two "spare" socket positions.

Noise Test jacks are provided for audible test of possible tube noise.

Portable Model: Grey leatherette case, 14" long x 12" x 5 $\frac{1}{2}$ ". Weight: 11 lbs. Hinged lid removable.

Bench Model: Welded steel cabinet, 13" long x 9 $\frac{1}{2}$ " x 5 $\frac{1}{2}$ ". Weight: 10 lbs. Rubber bumpers on base and back.

JACKSON

Fine Electrical Testing Instruments

JACKSON ELECTRICAL INSTRUMENT COMPANY, DAYTON, OHIO



MEETING OLD FRIENDS

EVERY day old friends drop in to see us—
familiar but long missed voices come
over the phone—men back from strange
lands, strange experiences.

Back home, back to the old job, the conversation swiftly turns to work. Pre-war dies and extrusion nozzles come out of the storage vault in perfect condition, ready for immediate production. Our men again produce pieces not made since before the war. Early designs, time tested and time proved, are

being made in increasing quantities.

Most of our men are back too. Production is humming along at a pace even greater than the wartime speed which won American Lava Corporation employees five awards of the Army-Navy E. We're busy, but if you ever had tools at American Lava Corporation, they are still here, ready for your use, and somehow we'll take care of you.

Welcome home, it's great to see you back again.



Original Award July 27, 1942
Second Award February 13, 1943
Third Award September 25, 1943
Fourth Award May 27, 1944
Fifth Award December 2, 1944

AMERICAN LAVA CORPORATION
CHATTANOOGA 5, TENNESSEE

43RD YEAR OF CERAMIC LEADERSHIP

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TRADE MARK REGISTERED U. S. PATENT OFFICE



DESIGN IMPROVEMENT

Problem: Improve and modernize design of radio cabinet for greater sales appeal and simplified production and assembly.

Solution: Richardson Plastics redesigned the cabinet, using Molded INSUROK. Units ordinarily assembled from several parts can be molded in one piece when Molded INSUROK is used. This makes possible improved, modern designs, greater sales appeal, more efficient production, and fewer assembly operations.

Why not consult Richardson if you are planning new products or the redesigning of present models? *Richardson Plastics* have the broad experience necessary for the prompt, efficient solving of difficult plastic problems. Let them help you improve both the appearance and performance of your products. Write today for information.



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Sales Offices: NEW YORK 6 • CLEVELAND 15 • DETROIT 2
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(Continued from page 44A)

Admission to Member

- Bishop, W. B., 212 W. Willow St., Normal, Ill.
- Boatright, B. C., 6349 Homewood Ave., Hollywood 28, Calif.
- Burchell, H. G., Naval Service Headquarters, Ottawa, Ont., Canada
- Chevalley, E. A., 102 S. Kilmer, Dayton, Ohio
- DeLoi, D. J., 196 S. First St., Brooklyn 11, N.Y.
- Engle, V. M., 1435 Ogden Ave., New York 52, N.Y.
- Fairfax, O. M., 1 Salisbury House, St. Aubyns, Hove, Sussex, England
- Fennessy, J. R., 65 Balmoral Dr., Southport, England
- Gabel, W., 5 Beech Spring Dr., Summit, N.J.
- Garrett, G. A., 1922 W. Gray St., Houston, Tex.
- Hall, J. A., 147 W. Pierrepont Ave., Rutherford, N.J.
- Hemphill, A. A., 1624 Natura Rd., Towson 4, Md.
- Hill, D. M., 507 Lathrop Ave., Boonton, N.J.
- Hoff, H. B., 750 Huron Rd., Cleveland 15, Ohio
- Hultgen, R. D., 542 Cedarhurst Ave., Dayton 7, Ohio
- Johnson, S. F., 3050 Maiden Lane, Altadena, Calif.
- Lader, L. J., 202 Wilmington Pl., S.E., Washington, D.C.
- Leonard, E. V., 3202 H McMichael St., Philadelphia 29, Pa.
- Lofton, J. H., 113 W. Clearfield Rd., Havertown, Pa.
- Lucian, T. F., Box 133, 424 W. St. Louis St., Lebanon, Ill.
- McGregor, J. C., Sperry Gyroscope Company, Inc., Garden City, L.I., N.Y.
- Melnicoe, S. A., 924 Stanyan St., San Francisco 17, Calif.
- Miller, G. H., 505 University Ave., Rochester 7, N.Y.
- Miller, S. E., 37-21-80 St., Jackson Heights, L.I., N.Y.
- Mondy, H. C., 741 Huffman Ave., Dayton 3, Ohio
- Nesbitt, A. D., 818 Public Square Bldg., Cleveland 13, Ohio
- Olson, J. H., Pacific Telephone and Telegraph Co., 601 Northern Life Tower, Seattle 1, Wash.
- Piety, E. W., Laura Ave., Centerville, Ohio
- Pullen, K. A., Jr., 8341-62 Ave., Rego Park, Brooklyn, N.Y.
- Robertson, C. B., 722 N. Broadway, Milwaukee 2, Wis.
- Russell, F. A., Newark College of Engineering, 367 High St., Newark 2, N.J.
- Saroop, M., Technical Corp., Lall Bagh, Lucknow U.P., India
- Veldhuis, A. C., Netherland Purchasing Commission, 41 E. 42 St., New York, N.Y.

(Continued on page 48A)



Sherron

AUDIO CONTROL DESK

Model SE-400

For Aural Monitoring

The Sherron Audio Control and Monitoring Console offers the aural technician or operator exclusive control in Television, FM or AM broadcasting.

All contacts are centrally located, so that the operator can meter and monitor the aural program with complete ease.

Among the many features of this unit are the following: seven (7) Audio Inputs; four (4) balanced ladder network for control of selector inputs; line equalizer; two (2) program amplifiers; inter-office communication; decibel indication for monitoring; two turntables, a complete aural control desk.

Another important feature of this unit is the fact that it is designed to permit expansion. The rack panels located in the center are readily removable; there are no wires to disconnect. All connections are made by means of plug-in jacks or sockets.



S H E R R O N E L E C T R O N I C S C O .

Subsidiary of Sherron Metallic Corp.

1201 Flushing Avenue • Brooklyn 6, N. Y.

"Where the Ideal is the Standard, Sherron Units are Standard Equipment."



"The whole is equal to the sum of all its parts"—Elementary? Of course—as simple and unchanging as all great principles. This axiom is a fundamental manufacturing creed at Stancor. We know the established excellence of Stancor Transformers is vitally dependent upon the perfection of each successive manufacturing step—from engineering considerations of individual specifications—through coil-winding, laminating, assembling, finishing, testing—and, finally, to careful packing for shipment.

All individual manufacturing operations have one common denominator—QUALITY—uncompromising, changeless QUALITY that continues to prove—"IN TRANSFORMERS, STANCOR GIVES MORE."



STANCOR
STANDARD TRANSFORMER CORPORATION
1500 NORTH HALSTED STREET CHICAGO 22, ILLINOIS



(Continued from page 464)

Ward, W. G., 52 Murray St., Peterborough, Ont., Canada
Webb, H. A., 520 Waltham St., Lexington 73, Mass.
Williams, E. E., General Electric Co., 1001 Wolf St., Syracuse 8, N. Y.
Zenner, R. E., 9409 Jefferson Ave., Brookfield, Ill.

Admission to Associate

Adams, J. T., 408 Diamond Ave., Gaithersburg, Md.
Adams, R. L., 8317 Garfield Ave., Bell Gardens, Calif.
Akin, R. H., 230 N. Fairview St., Burbank, Calif.
Albrough, C. E., Box 370, Ingersoll, Ont., Canada
Austin, J. B., Jr., 1424 W. Allegheny Ave., Philadelphia 32, Pa.
Balakrishnan, T. P., 7 Loge Bonheur, Off Station Rd., Mahim, Bombay, India
Baluta, R. E., 2700 Wisconsin Ave., N.W., Washington 7, D. C.
Bankson, H. D., Box 321, Main Office, Arlington, Va.
Bannett, D. R., 436 Fort Washington Ave., New York 33, N. Y.
Bansal, S. K., Marconi School of Wireless Communication, Arbour Lane, Chelmsford, Essex, England
Barna, W. W., Dept. of Physics, Tulane University of Louisiana, New Orleans 15, La.
Barnes, R., Hotel Victoria, Northumberland Ave., London W.C. 2, England
Barsky, H. S., 2420 Bigler Terrace, Philadelphia 45, Pa.
Bellew, R. W., 120 Church St., Newton 58, Mass.
Bessette, R. F., 104 Dunmoreland St., Springfield 9, Mass.
Birnie, A., 711 Churchill Ave., Westboro, Ont., Canada
Bristol, R. W., 155 Perry St., New York 14, N. Y.
Carl, J. E., 4701 E. Broad St., Columbus 9, Ohio
Buchter, T. W., 3408—150 Pl., Flushing, L. I., N. Y.
Cagle, H., c/o Fleet Post Office, New York, N. Y.
Carlson, B. V., 4822 Beech St., San Diego 2, Calif.
Carter, G. W., 5224—11 St. N., Arlington, Va.
Chu, C. C., Union Switch and Signal Co., Swissvale, Pa.
Conrad, E. G., 1759—14 St., Santa Monica, Calif.
Dance, D. W., 201C S. Oyster Bay Ave., Bremerton, Wash.
Das Gupta, S., c/o E. T. Dept., Indian Institute of Science, P.O. Mallewaran, Bangalore, India
Davies, R. J. C., 13, Glanmor Crescent, Swansea, England

(Continued on page 52A)

ML889A

Machlett improved design

provides longer life and better performance

The ML889A and ML889RA are outstanding examples of Machlett's ability to apply its time-tested and advanced techniques to tubes of standard design with resulting improvement in construction, performance and life. They incorporate the "know-how" that has made Machlett electron tubes demonstrably superior since 1897. Consider these advanced features that give you better tubes with longer and more uniform performance:

1. Heavy Kovar sections are used instead of the conventional and more fragile feather-edge copper seals. Result—greatly increased mechanical strength, lessening danger of breakage in handling and installation.

2. Filament and grid terminals are solid, continuous and of high conductivity copper. Contact surfaces gold-plated to minimize contact resistance.

3. Special grid and filament assembly reduces lead inductance, permitting safer operation as high as 50 mc. with full input and output.

4. Internal structure greatly strengthened, assuring constant and more uniform grid-filament-plate spacing.

5. One piece copper anode and shield assure uniform internal surface, permit maximum accuracy of assembly, provide complete

shielding of anode seal and reduce difficult-to-outgas interfaces normally found in tubes of this type.

6. All internal parts completely processed by Machlett's special techniques which prevent contamination and assure complete and permanent out-gassing.

7. Tube "pumped" by unique Machlett straight line, high voltage exhaust process assuring same high standards as characterize the Machlett line of high-voltage X-ray tubes.

These perfected tubes for high frequency heating and communications purposes constitute a further contribution by Machlett of quality, durability and long life to the electron tube art. Now available for initial installation and renewal purposes. For further details, write Machlett Laboratories, Incorporated, Springdale, Connecticut.

General Characteristics — ML889A	
Filament Voltage	11 volts
Filament Current	125 amperes
Amplification Factor	21
Maximum Frequency for Full Power	50 mc.
Capacity, Grid to Plate	17.8 uuf.
Capacity, Grid to Filament	19.5 uuf.
Capacity, Plate to Filament	2.5 uuf.
Cooling	Water
Water	3-6 gals/min.
Air (ML889RA)	15 cfm.

At reduced power, may be operated at frequencies as high as 150 megacycles.



ML889RA, Air-cooled version of the ML889A, may be operated at full output at frequencies up to 25 megacycles, at reduced power up to 100 mc.

MACHLETT

APPLIES TO RADIO AND INDUSTRIAL USES
ITS **44** YEARS OF ELECTRON TUBE EXPERIENCE

**JUNIOR
ENGINEER
COLLEGE GRADUATE**

- No experience necessary.
- Required for circuit and general radio tube applications work.

Write or Call
Personnel Dept.

TUNG-SOL LAMP WORKS, Inc.
370 Orange Street
Newark 7, N.J.

**PURCHASING
AGENT**

Excellent opportunity for purchasing agent with a substantial experience in purchasing all types of material required for manufacturing a high quality line of radio-phonograph combinations. In responding, indicate in detail experience, education and salary expected.

**FREED RADIO
CORPORATION**
200 Hudson Street
New York 13, N.Y.

POSITIONS OPEN

The following positions of interest to I.R.E. members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No. The Institute reserves the right to refuse any announcement without giving a reason for the refusal.

PROCEEDINGS of the I.R.E.
330 West 42nd Street, New York 18, N.Y.

SENIOR ENGINEER

Newly formed organization for manufacture of radio receiver sets requires experienced man to assume charge of production and general development. Must be able to lay out, set up, and properly equip modern assembly line. New plant in New York area. Excellent opportunity for permanent connection. All inquiries treated confidential. Box 409.

RADIO AND ELECTRONICS ENGINEER

Manufacturer established since 1921 has permanent opening for engineer capable of designing circuits and thoroughly familiar with designing of condensers, sockets, jacks, plugs, etc. more from electrical than mechanical angle. Box 410.

RADIO SPEAKER ENGINEER

Position for a present chief engineer or assistant with confidence backed by experience in design and economical production of radio speakers. Outstanding opportunity to establish yourself as important member of our company. Salary and bonus. Eventual participation in company stock after proof of performance. Massachusetts location. Interview arranged at our expense. Write full details of experience, past and present positions, earnings etc. to enable us to accurately judge you. Replies held confidential. Our men know of this ad. Box 411.

DESIGN ENGINEER

To design and develop production test equipment and fixture used to check R.F. coils and condensers. Knowledge and experience on design of electronic test equipment essential and some radar experience desirable. Salary open. Location Newark. Box 412.

**APPLIED PHYSICISTS, COMMUNICATION
AND ELECTRONICS ENGINEERS**

Research minded with good theoretical background to engage in research in aeronautical science, advanced degrees preferred. Salary commensurate with qualifications. Address replies to Cornell Aeronautical Laboratory, Personnel Office, Box 56, Buffalo 5, N.Y. Replies will be held in strict confidence.

ACOUSTICAL ENGINEER

Primarily in the field of architectural acoustics, who is qualified to determine the acoustical properties of broadcasting and recording studios and to develop new methods and equipment for the measurement of these characteristics. A working knowledge of the acoustical problems associated with microphones and loudspeakers is also necessary.

Applications and requests for interviews should be made in writing to W. B.

(Continued on page 56A)

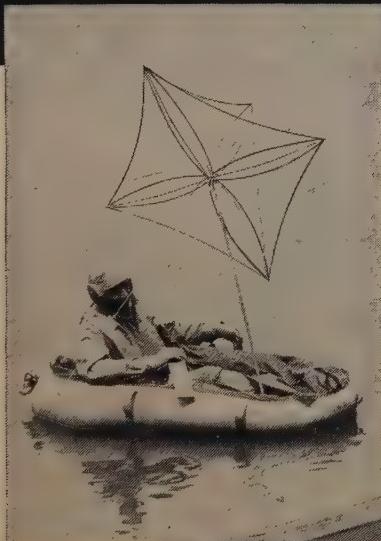


Larvie Laboratories
RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

they wanted
to catch radar beams

with metal

"Spider Webs!"



The reflector in use...and as it is packed

Eleven different "spider webs" of Monel mesh in the Vendo reflector catch radar beams approaching from any quarter. The mesh, knit from 0.0035-inch Monel wire, is furnished by Metal Textile Corp., Orange, N. J.

One of the problems was to make the reflector compact enough to fit in the smallest life raft pack. By using easily-folded Monel mesh, the unit can be stowed in a waxed cardboard carton, only 25" long and 1 3/4" square.

Peacetime possibilities include use as an aerial for home radios. One report cites tremendously improved reception.

In 1942, Eddie Rickenbacker and his companions crash-landed in the Pacific. For 22 days, airplanes combed the sky before sighting them.

Three years later, airmen forced down at sea were being found in a matter of hours . . . on blackest nights . . . in roughest weather.

...for radar was being used to locate friend as well as foe!

A metal reflector, developed by the National Defense Research Committee, turned the trick.

Known as the "Corner Reflector," it enabled life rafts to be easily detected by radar-equipped rescue craft.

To make the reflector, 4 ounces of wire mesh are formed into 11 triangular webs and stretched out on a collapsible framework. It is this mesh which reflects the radar waves and sends them back to appear as spots on the radar scopes of searching airplanes or ships.

Working with the Army and Navy, Vendo Company of Kansas City tested many metals for the mesh.

The metal had to offer just the right electrical and electronic characteristics. The metal had to be strong, so that the delicate mesh would not be ripped apart by winds. And (*of greatest importance*), it had to resist corrosion by salt spray. For the slightest corrosion would set up high resistance at the thousands of mesh contacts, and seriously cut down over-all conductivity.

Of all the materials tested, only one was found to possess all the properties needed.

That was knit Monel mesh.

Remember Monel and other INCO Nickel Alloys whenever you need a "hard-to-find" combination of properties for electrical or electronic applications. For more information on metals that fight . . . corrosion . . . wear . . . fatigue . . . heat . . . stress . . . write for "Tremendous Trifles."

THE INTERNATIONAL NICKEL COMPANY, INC.
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All Engineers and Designers of

MOTORS GENERATORS MAGNETOS REMOTE INDICATORS

should consider

PERMANENT MAGNETS



These Permanent Magnets are representative of some that have been designed for Motors, Generators, and allied equipment. If you have not used Permanent Magnets for these applications . . . consult us for engineering advice.

Write for Technical Bulletin—“Permanent Magnets for Industry,” containing valuable data on design, production characteristics and applications of Permanent Magnets.

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Specialists in the Manufacture of
ALNICO PERMANENT MAGNETS



(Continued from page 48A)

Dean, R. D., 156—77 St., Brooklyn 9, N. Y.

Dee, H. E., 1931—16 St., N.W., Washington 9, D. C.

DeLany, R. H., 1311 Terminal Tower, Cleveland 13, Ohio

Dewar, H. D., 513 S. Tryon, c/o B. O. Vannort, Charlotte 2, N. C.

Dillow, J. C., 540 N. Ninth St., Corvallis, Ore.

Doolittle, K. H., 6732—35th Ave. S., Seattle 8, Wash.

Dowell, K. P., Western Electric Co., Radio Div., F.E.F., 120 Broadway, New York 5, N. Y.

Elnegaard, E., Baunegaardsvej 2 B, Gentofte, Copenhagen, Denmark

Ely, C. H., 1502 Schantz Ave., Dayton 9, Ohio

Emery, R. C., 166A Maple Ave., Red Bank, N. J.

Fligel, F. J., 1325 N.W. 16 St. Oklahoma City 6, Okla.

Fockler, W. G., 91 Paulison Ave., Passaic, N. J.

Fox, B., 268 E. Durard Rd., Philadelphia 19, Pa.

Fredlund, F. A., 1024 E. Second St., National City, Calif.

Freed, R. D., 1140 Fifth Ave., New York 28, N. Y.

Futterman, M., 3050½ Wellington Rd., Los Angeles 16, Calif.

Gerlach, A. A., 4020 Overhill Ave., Chicago 34, Ill.

Getting, H. W., Jr., 42 Birch Brook Rd., Bronxville, N. Y.

Gillen, R. G., W2XMN, Alpine, N. J.

Gleimer, B., 1349 Stratford Ave., New York 59, N. Y.

Greenberg, D., 524 Powell St., Brooklyn 12, N. Y.

Gricher, F. A., 27 Grand Pl., Arlington, N. J.

Gundy, P. L., Graybar Electric Co., 55 W. Canfield Ave., Detroit, Mich.

Gurd, R. H., 185 Dundas St., London, Canada

Habich, F. L., 55 Hedges Ave., Chatham, N. J.

Hammond, E., Mount Byrdges, Ont., Canada

Hampton, W., 49 Alleghany Rd., Hampton, Va.

Hansen, P., Petersborgvej 3B, Copenhagen, Denmark

Harr, F. I., WORD, Spartanburg, S. C.

Hengstler, J. J., 6222 Shadyside Ave., Capitol Heights, Md.

Holmes, D. B., 22 Rose Ave., Madison, N. J.

Hubbert, E. C., 1000 Chestnut St., Philadelphia 5, Pa.

Hutchinson, D. S., 827 Lovett St., London, Ont., Canada

Jarboe, R. A., 3520 Agnes St., Kansas City, Mo.

Jensen, S. E., Gimsing, Struer, Denmark

Johnson, P. I., Diamond Head Dr. at Coconut Rd., Honolulu, Hawaii

(Continued on page 54A)

"ZIRMET CUTS PUMPING TIME 30%"

Says Taylor Tubes, Inc.

Zirmet Benefits Both Tube Manufacturer and Tube User

Interested in reducing pumping time? Then you'll certainly want to look over these excerpts from a letter sent us by Taylor Tubes, Inc., commenting on their use of Zirmet (Foote Ductile Zirconium)...

"The application of the Zirconium Metal to the fins of the T-125 means that we are able to cut our pumping time by about thirty per cent, and the gettering action, while the tube is actually in operation, is very good.

"The type T-125 tube is widely used in diathermy at frequencies up to 70 MC, and of course, in Amateur Radio opera-



Taylor Type 125 Tube for diathermy and radio applications.
tion at the present time, at 28 to 30 MC.
We feel that the Metal is most effective
in obtaining a higher order of vacuum in



Carbon Anode of Taylor Type 125 Tube. Four pieces of Zirmet
1/16" x 1 1/2" x .005" are welded to the molybdenum fins.

this particular application. It is well worth the small added expense."

Zirmet is literally "what the doctor ordered" and may prove equally effective for you.

Many Advantages for Tube Maker and User

If you are a tube manufacturer, the use of Zirmet as a continuous getter means less pumping time, better vacuum, less shrinkage, clean tubes, and, naturally, satisfied customers. If you are a tube user, you can count on better emission and longer life when you buy a tube containing Zirmet the *continuous getter*.

Investigate Zirmet now. Write or telephone our engineers today for details and prices.

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MINERAL COMPANY

A Step Ahead
in Industrial Ores
and Chemicals

Chemicals • Ores • Metals • Alloys

PHILADELPHIA • ASBESTOS • EXTON, PENNSYLVANIA

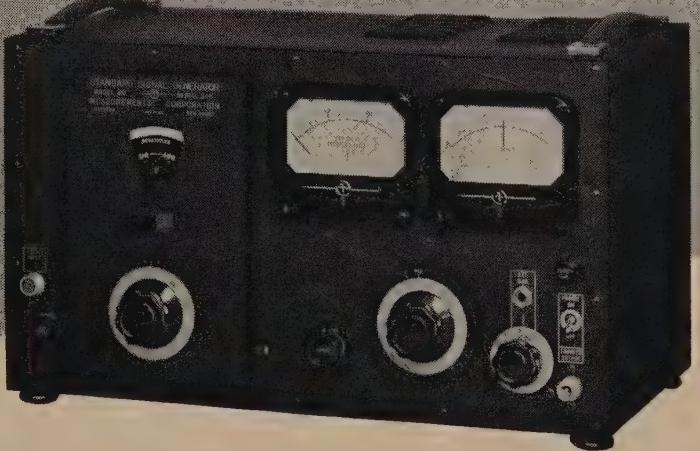
Home Office: 502 GERMANTOWN TRUST COMPANY BLDG., PHILA. 44, PA.

West Coast Representative: Griffin Chemical Co., San Francisco, Cal.

Laboratory Standard

INSTRUMENTS

built for Accuracy and Endurance



STANDARD SIGNAL GENERATOR Model 80

This instrument is well suited for development and production testing in the recently allocated FM and Television bands. The absence of stray fields or leakage permits accurate measurement of the most sensitive receivers.

SPECIFICATIONS:

CARRIER FREQUENCY RANGE: 2 to 400 megacycles.

OUTPUT: 0.1 to 100,000 microvolts. 50 ohms output impedance

MODULATION: AM 0 to 30% at 400 or 1000 cycles internal. Jack for external audio modulation.

Video modulation jack for connection of external pulse generator.

POWER SUPPLY: 117 volts, 50-60 cycles.

DIMENSIONS: Width 19", Height 10½", Depth 9½".

WEIGHT: Approximately 35 lbs.

PRICE: \$465.00 f.o.b. Boonton

Suitable connection cables and matching pads can be supplied on order.



Model 62

VACUUM TUBE VOLTmeter

SPECIFICATIONS:

RANGE: Push button selection of five ranges—1, 3, 10, 30 and 100 volts a.c. or d.c.

ACCURACY: 2% of full scale. Usable from 50 cycles to 150 megacycles.

INDICATION: Linear for d.c. and calibrated to indicate r.m.s. values of a sine-wave or 71% of the peak value of a complex wave on a.c.

POWER SUPPLY: 115 volts, 40-60 cycles—no batteries.

DIMENSIONS: 4½" wide, 6" high, and 8½" deep.

WEIGHT: Approximately six pounds.

PRICE: \$135.00 f.o.b. Boonton, N. J. Immediate Delivery

MANUFACTURERS OF
Standard Signal Generators
Pulse Generators
FM Signal Generators
Square Wave Generators
Vacuum Tube Voltmeters
UHF Radio Noise & Field
Strength Meters
Capacity Bridges
Megohm Meters
Phase Sequence Indicators
Television and FM Test
Equipment

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

Membership

(Continued from page 52A)

Johnston, J. G., 3545—21 St., San Francisco 14, Calif.

Joseph, H. M., 1729 Madison Pl., Brooklyn 29, N. Y.

Kar, D. C., P60B, New Shambazar St., P.O. Shambazar, Calcutta, India
Keenan, S. G., Box 4405 Westpark, Bremerton, Wash.

Kirkman, D., Admiralty Hostel, Wormley, Godalming, Surrey, England

Koeppel, B. W., 39 N. Benton St., Cape Girardeau, Mo.

Konig, V. A. Y., RFD 1, Edgewater Park, Grafton, Wis.

Langgaard, E., Duntzfelts 10, Hellerup, Denmark

Ley, J. F., Cove Rd., Oyster Bay, L. I., N. Y.

Lillie, C. E., 64 Pheasant Hill St., Westwood, Mass.

Lindstrom, E. B., Forskningsinstitutet for Fysik, Stockholm 50, Sweden

Lorentz, E. F., Commercial Radio Equipment Co., 1319 F St., N.W., Washington 4, D. C.

Lozowick, J. H., 176 Shepard Ave., Newark 8, N. J.

Mardock, R. W., 170 Jackson St., Mineola, N. Y.

Marlow, D. G., 16 Elm St., Garden City, L. I., N. Y.

McLaughland, W. S., c/o Patrick, 4, Mearns St., Greenock, Renfrewshire, Scotland

McManis, L. B., Watson Laboratories, WLMDA, Red Bank, N. J.

McNeese, S. J., 719 Fourth St., Coronado, Calif.

Mitchell, P. P., 1603 Wells Ave., Bakersfield, Calif.

Muhling, C. H., 104 Northwood St., Leederville, Perth, Western Australia

Nachtigall, A. J., 3521 Nichols Ave. S.E., Washington 20, D. C.

Natarajan, R., "Sunder Bavan," Krishnamachary Rd., Cathedral Post, Madras, India

Nixey, W. A., 74 Boullie St., London, Ont., Canada

Occhiogross, T., 84 Barker Ave., Eatontown, N. J.

Overton, B. H., Box 777, Leesburg, Fla.

Paley, W. D., 74 Post Ave., New York 34, N. Y.

Parsons, J. R., 741—51 St., S.E., Washington 19, D. C.

Pascual T., A., Chiloe 5399, Santiago de Chile

Pattee, H. H., 2022 N. Burling St., Chicago 14, Ill.

Pedersen, N. T., Skjoldagervej 24, Gentofte, Denmark

Quealy, O. H., 612 Bank St., Ottawa, Ont., Canada

Richards, T. K., 1700 S. Figueroa, Los Angeles 15, Calif.

Ricker, F. J., 46 Ashford St., Boston 34, Mass.

Rock, K. C., Jr., 215 E. Lake, Fort Collins, Colo.

Roy, K., Flora Cottage, Pabna, Bengal, India

Sadler, W. E., Broadway, Greenlawn, L. I., N. Y.

(Continued on page 56A)

Use Standard Parts • Save Time And Money

Automatic Manufacturing Corp.

*900 Passaic Avenue
East Newark, N. J.*

Manufacturers of

*Intermediate Frequency Transformers
Mica Trimmer Condensers*



For FM and TV

NEW ANDREW COAXIAL CABLE WITH
51.5 OHMS IMPEDANCE!

Meets Rigid FM-TV Standards

A new coaxial cable, especially designed for FM and TV use, is now a reality at the Andrew Co. Scheduled for mid-June delivery to the first orders received, these new cables, in 4 sizes, introduce the following important engineering features:

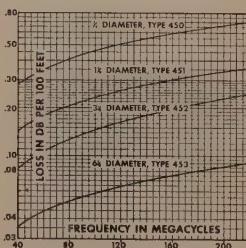
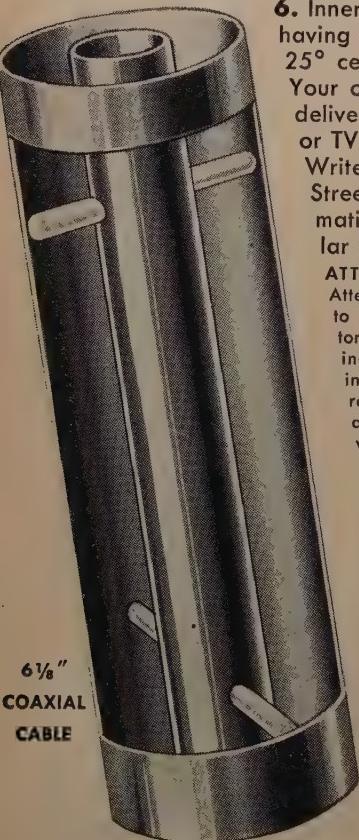
1. Characteristic impedance of 51.5 ohms. (The regular Andrew cables for AM applications have a nominal impedance of 70 ohms.)
 2. Connectors and associated fittings have been engineered with special care to avoid reflections and discontinuities. Being completely solderless, these fittings simplify installation and eliminate problems of flux corrosion and pressure leaks.
 3. Insulators are spaced 12 inches apart in the 3 large size cables, and 6 inches in the $\frac{7}{8}$ -inch cable.
 4. Improved low loss insulation material is used, having a dielectric constant of 6.0 and a maximum loss factor of .004 at 100 mc.
 5. Close tolerances have been established on conductor and insulator dimensions, in order to maintain a constant characteristic impedance.
 6. Inner and outer conductors are made of copper having a minimum conductivity of 95% IACS at 25° centigrade.
- Your order now is the best assurance of early delivery on this new coaxial cable for your FM or TV installation.

Write or wire the Andrew Co., 363 East 75th Street, Chicago 19, Illinois, for complete information or engineering advice on your particular application.

ATTENUATION CURVE

Attenuation is calculated to provide for conductor and insulator loss, including a 10% derating factor to allow for resistance of fittings and for deterioration with time.

- The new 51.5 ohm air insulated coaxial cable for FM and TV comes in 4 sizes, priced tentatively as follows: $\frac{7}{8}$ ", 42c per ft.; $1\frac{1}{2}$ ", 90c per ft.; $3\frac{1}{8}$ ", \$2.15 per ft.; $6\frac{1}{8}$ ", \$5.20 per ft. Andrew Co. also manufactures a complete line of accessories for coaxial cables.



Membership

(Continued from page 54A)

- Samulon, H., Ottikerstrasse 25, Zurich, Switzerland
- Schmidt, J. C., 8118 S. New Hampshire Ave., Los Angeles 44, Calif.
- Schulz, H. R., 531 E. Lincoln Ave., Mt. Vernon, N. Y.
- Schwartz, T. F., 30 W. 90 St., New York 24, N. Y.
- Seidel, H. W., 247 W. 31 St., Baltimore 11, Md.
- Sills, M. M., 56 Featherbed Lane, New York 52, N. Y.
- Smith, E. K., Jr., Engineering Dept., Mutual Broadcasting System, 1440 Broadway, New York 18, N. Y.
- Spehr, C. J., RFD 1, Box 94, Diller, Nebr.
- Stefansky, A., 3584 Virginia St., Gary, Ind.
- Stetzel, G. I., 7 Elm St., Garden City, L. I., N. Y.
- Stevenson, E. B., 123 Caron St., Wrightsville, Que., Canada
- Sundberg, A. A., 4059 Murdock Ave., Bronx 66, N. Y.
- Stillwaser, J. 419 S. Darling St., Angola, Ind.
- Strouss, W. S., 1010 Oxford Rd. N.E., Atlanta, Ga.
- Stultz, L. R., 111 N. 16 St., East Orange, N. J.
- Swenson, W. J., 3713 Wheeler Rd., S.E., Washington 20, D. C.
- Tang, K. C., Box 28, White Haven, Pa.
- Tetrault, F. J., 134 Leslie St., Toronto, Ont., Canada
- Thomson, M., 11635—91 St., Edmonton, Alberta, Canada
- Victor, H. W., 110 Seaman Ave., New York 34, N. Y.
- Volger, W. A., 406 Prospect Ave., Hackensack, N. J.
- Waller, W. E., 141 Joralemon St., Brooklyn 2, N. Y.
- Weller, B. L., Remington Arms Co., Bridgeport, Conn.
- Wiesner, L., 118-65 Metropolitan Ave., Kew Gardens 15, L. I., N. Y.
- Williams, S. B., 4847 N. 41 St., Milwaukee 9, Wis.
- York, E. P., 1R3, Sperry Gyroscope Co. Inc., Garden City, L. I., N. Y.
- Zerber, F. A., 1021½ E. Second St., Michigan City, Ind.

Positions Open

(Continued from page 50A)

Lodge, Director of Engineering, Columbia Broadcasting System, Inc., New York 22, N.Y.

CHIEF MANAGING ENGINEER AND RESEARCH ENGINEERS

Chief Managing Engineer to take full charge of a division of a large manufacturing organization. Must have extensive experience in communications field, with substantial background in electronics and micro-wave research and product development. Salary \$12,000 to \$15,000.

Research Engineers with thorough experience in electronics, and micro-wave development. Salary \$5,000 to \$6,000.

Write qualifications to Boyd King, 10 Rockefeller Plaza, New York 20, N.Y.

Ex-G.I. Seeks Job



Can you use this finger-size 10 kw Triode?

Doubtless there are many electronic experimenters and designers working in the intermediate micro-wave range with need for just such a triode. Designed and built by National Union for advanced radar installations, this N.U. 3C37 should prove a "natural" for engineers concerned with instruments for aircraft, navigation, railroads, communication relay transmission and many related applications. Here is the only tube of its kind—a newcomer to electronics, yet an experienced veteran proved under the most rigorous service conditions. There are electronic jobs it can do better than they have ever before been done—problems it can solve for the first time. Why not write us about the N.U. 3C37? Or come to our laboratories and talk it over with a National Union engineer.

Qualifications of the N.U. 3C37

- Delivers 10 KW peak RF power output at frequencies as high as 1150 megacycles.
- Anode and grid dissipation capabilities are adequate to enable the tube to withstand large momentary overloads without damage or distortion of electrical characteristics.
- Internal and external surfaces are silver plated to minimize skin resistance and RF losses.
- Specially constructed radiator greatly reduces RF losses. Permits operation at duty cycles of 1% with air-blast cooling.
- Anode radiator of silver plated copper efficiently transfers heat to any resonator of which it becomes a part.
- Negligible frequency drift due to cylindrical construction and closely controlled mechanical tolerances.
- Maximum mechanical strength.

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RADIO AND ELECTRON TUBES**

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ENDURANCE

Your profit from the use of any kind of equipment hinges on its quality of performance—and on its endurance. Electronic Engineering Company transformers are built ruggedly to give lasting service under all conditions. If you have special and difficult transformer problems, feel free to make use of the finest engineering talent and most complete electronic laboratories.

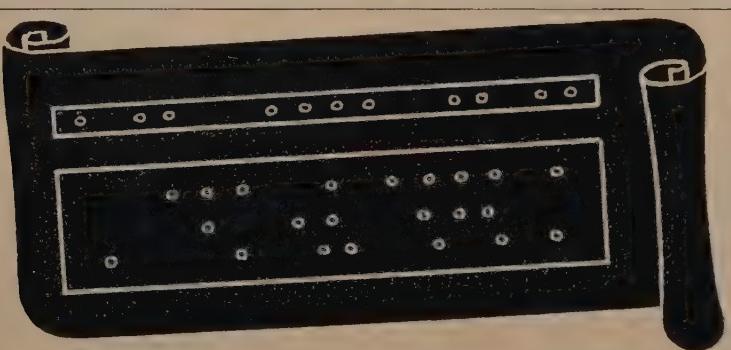
Write or call today.

"SPECIALIZED
Transformer
ENGINEERS"

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CHICAGO 47, ILL.



Now You Can Get TERMINAL BOARDS

Custom Made to Your Specifications

Don't waste time drilling and cutting terminal boards and mounting terminal lugs—let C.T.C. do it for you. Just send your complete specifications and we'll make up the boards to meet your most exacting requirements.

You'll get the boards in less time than you think, and they'll be com-

plete, ready to use, with quick soldering C.T.C. Lugs firmly anchored in exact position, and linen bakelite boards perfectly cut and finished.

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Why not let us quote on your specifications today.



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456 Concord Avenue • Cambridge 38, Mass.

Why You Should Join The Institute of Radio Engineers

R. C. POULTER

In the October, 1945, issue of *Radio and Appliance Sales*, the following interesting article by an active member of the I.R.E. was published. R. C. Poulter, the author, has kindly consented to let us reprint it in its entirety.

The Editor

No engineering society has served the war effort of the United Nations to better advantage than The Institute of Radio Engineers, and none will serve the cause of peace more effectively.

During wartime the membership of I.R.E. rose rapidly as more and more engineers and technicians turned to it as a source of factual information and inspiration. And with the tremendous amount of technical data and knowledge concerning secret wartime developments soon to be released and for which important peacetime applications will be found, the Institute is bound to be the central point through which thousands upon thousands of engineers and technicians will turn for guidance.

Engineers and technicians have two responsibilities which they cannot—must not—shirk. One is to keep themselves fully posted on all important developments in the art of radio communications and electronics. The other is to pass along to others the knowledge which they themselves have gained over the years.

There is only one way in which they can be sure of meeting both of these responsibilities and that is through membership in the I.R.E. and by participating in its activities whenever the opportunity arises.

In the months and years ahead we engineers and technicians in Canada must take full advantage of every facility the Institute has to offer if we are to keep radio and electronics in the front rank of our country's industries.

We owe it to the general public, to our employers, our fellow workers and to ourselves to make sure that we are doing and shall continue to do everything in our power to push this great industry ahead.

Our responsibilities are much greater than most of us realize, and this is particularly true in the "reconstruction period" we are now in. To a very considerable extent, our efforts will influence employment trends. By keeping up public interest in radio and electronics, by developing new and improved products and services we can create a constantly growing demand for the industry's products and thus create more jobs for more men and women.

To accomplish this we must, therefore, keep ourselves fully informed as to what is going on in radio and electronics, and the I.R.E. offers by far the best way of achieving this aim.

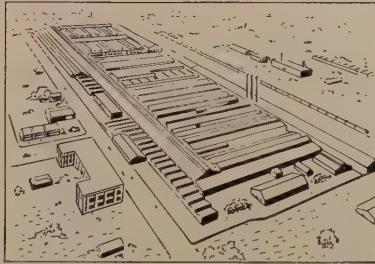
The Institute of Radio Engineers is an international body with some 16,000 members scattered over the far corners of the earth. There are active sections throughout the United States, Canada, and the Argent-

(Continued on page 62A)

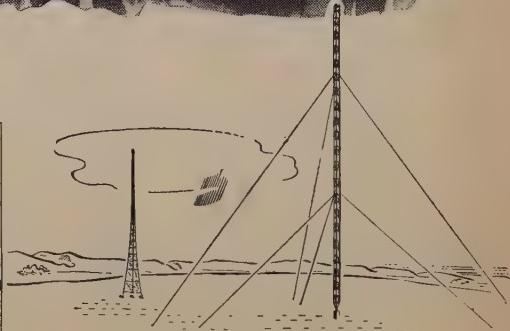
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are ready to help you plan your
radio tower installation for
maximum
efficiency



• Truscon engineers will help you select proper types and heights of towers for optimum efficiency.



• Truscon engineers have behind them over forty years of experience in the development and fabrication of steel products.



• Truscon engineers have designed towers to meet each advance in radio broadcast technique.

CALL IN TRUSCON ENGINEERS during the early stages of your plans for antenna installations. Their experience assures satisfactory, trouble free operation today — tomorrow — and during the years to come.

1946 is the year of decision and transition. Truscon can help toward the correct antenna decision — toward orderly and efficient transition to the newest in radio.

Truscon engineering consultation is yours without obligation. Write or phone our home office at Youngstown, Ohio, or any of our numerous and conveniently located district sales offices.

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 HELPFUL PARTNER
 to more than*

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CREI Spare-Time Technical Training is Preparing Alert Radiomen for Better-Paying Positions by Increasing Their Efficiency and Individual Worth to the Industry—

Admirable and creditable to the radio industry are the high-calibre men who do not merely relax into the routine of their jobs, but devote their own spare time and money to become better radiomen. They are preparing for advancement by increasing their technical ability. CREI has proved to be a "helpful partner" . . . by enabling such men to successfully step into positions of greater responsibility.

The success of CREI men who have spent their spare time in preparation for promotion should prove an incentive for others to investigate thoroughly the opportunities that this advanced training makes possible. CREI is interested in any serious-minded radioman who realizes the value of a planned program of home study technical training in Practical Radio-Electronics Engineering.

Alert engineers are encouraging CREI training for their employees. Your recommendation of our home study courses to your associates will increase the efficiency of your engineering staff.

The CREI "Employer's Plan" is useful for the up-grading of technical personnel in manufacturing, AM, FM, and television broadcasting, communications, industrial electronics, including the following:

Engineers	Testers
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Laboratory	Field Servicemen
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Your request will promptly bring an outline of the plan, as now in use with other organizations, and intimate details will follow when your particular needs are known. No obligation or cost, of course.

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E. H. RIETZKE, President

Home Study Courses in Practical Radio-Electronics Engineering for Professional Self-Improvements

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 WASHINGTON 10, D.C.**

Why You Should Join The Institute of Radio Engineers

(Continued from page 58A)

tive, which hold regular meetings at which experts in all branches of the art deliver technical papers on the subjects in which they have specialized.

WHAT THE INSTITUTE DOES

1. Holds regular technical meetings.
2. Publishes the PROCEEDINGS OF THE I.R.E. monthly.
3. Establishes standards on definition, test procedure, ratings, nomenclature, symbols, etc.
4. Recognizes outstanding achievements by award of honors.
5. Keeps its members up to date on developments in the radio-and-electronic art.
6. Increases the prestige of its members.

Every radio engineer and technician should be a member!

In Canada we have over 500 members, and there are four sections located in London, Montreal, Ottawa and Toronto. A Canadian I.R.E. Council, founded last year, will serve to co-ordinate the activities of the sections, to serve as a link between Canadian members and the Board of Directors.

The Institute of Radio Engineers was established long before broadcasting came into being. On May 13, 1912, the Institute was formed through the merger of two organizations active in the technical field. One of these was the Wireless Institute, the headquarters of which were in New York City, and the other, known as the Society of Wireless Telegraph Engineers, was located in Boston. It is the object of the Institute to advance the theory and practice of radio and electronics and allied branches of engineers. It includes among its members those who have played prominent parts in the development of radio throughout the world.

An important service which the Institute renders to its members is the publication of technical papers. In addition many papers are presented at Section meetings where discussions may be effective in increasing the knowledge of those present.

The PROCEEDINGS OF THE I.R.E.¹ is the official publication of the Institute and in it are published first-rate technical papers, discussions, communications and news of vital interest to everyone in radio. The PROCEEDINGS appears monthly and constitutes a most valuable reference.

The Institute also publishes Standard reports, the work of its specialized Standards committees, and these establish definite standards for the industry in definitions, test procedure, ratings, nomenclature, symbols, etc.

Yearbooks are published at irregular intervals, eleven editions having appeared so far.

The Institute recognizes each year the outstanding achievements in the radio com-

(Continued on page 68A)

¹ Editor's Note: Since the publication of this article, the name of the official magazine of the Institute of Radio Engineers has been changed to PROCEEDINGS OF THE I.R.E. AND WAVES AND ELECTRONS.

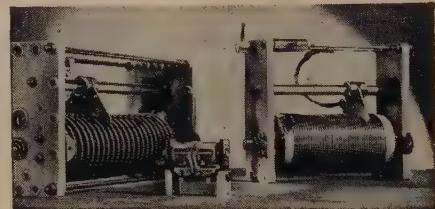
INDUCTOR HEADQUARTERS

B & W



MINIATURE R-F INDUCTORS

B & W MININDUCTORS meet the fast-growing need for finely-made miniature coils for modern high-frequency services. Standard diameters range from $\frac{1}{2}$ " to $1\frac{1}{4}$ ". AIR-WOUND construction assures an amazingly high Q characteristic. Mininductors are supplied in any length and for any type of mounting. Coupling links and other features as required. Write for Bulletin.



GENERAL PURPOSE ROTARY COILS

From midget sizes only a few inches long with dual opposed windings or other special features to giant units for transmitting, dielectric heating or other uses B & W Rotary Coils providing continuous adjustment throughout the entire length of the winding, are supplied in a wide variety of types. Submit details of your application for recommendation by B & W engineers.

EDGE-WISE WOUND INDUCTORS



Furnished in diameters from $1\frac{1}{4}$ " to upward of 10". Minimum size of copper strip $3/16$ " x $.050"$; maximum 1" x $.250$ ". Inside or outside mountings available, plain or tapped coil styles. Rotary or continuously adjustable units supplied with either inside or outside contacts. Write for details.

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A NEW, INEXPENSIVE
Cathode-ray
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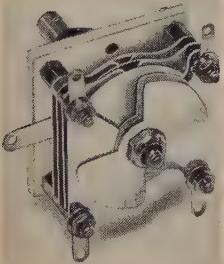
- Ideal for school and college classroom demonstrations!
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DUMONT Precision Electronics & Television

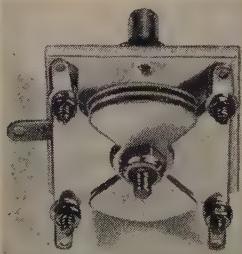
ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J. U. S. A.

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A NEW LINE OF
CARDWELL
MIDGET CONDENSERS
 for
U. H. F.



PL-6113

(Type ER-14-BF/SL)
 Range: 14-11 mmf. (approx.)
 (Minimum capacity loaded by circular rotor plates—for a High "C" circuit.)



PL-6076

(Type ER-6-BF/S)
 Range: 6-2.5 mmf (approx.)

The "Butterfly" rotor plates with 90 degree stators insure:

**ELECTRICAL SYMMETRY
 LOW DISTRIBUTED INDUCTANCE**

Features

- Circular plates for low loss fixed minimum permits adjustable band spread.
- No moving contacts.
- Plates easily removed to change capacity range.
- Isolantite Insulation.
- Single Hole Mounting.
- Small size—made to fit standard Cardwell Trim-air hardware.



Other sizes available. Inquiries will be promptly answered.

THE ALLEN D. CARDWELL MFG. CORP.

Main Office: 81 Prospect Street,
 Brooklyn 1, N. Y.

Factories: Plainville, Conn.—Brooklyn, N.Y.

News and New Products

William G. Broughton (A'30) with new General Electric Phasitron modulator tube to be used in a new and revolutionary simplified circuit in all postwar FM transmitters built by the company. In the background is a sketch showing the internal parts of the tube.

The new circuit and Phasitron tube development are as fundamentally new and important to FM broadcasting as the introduction of crystal control was for AM broadcasting, G.E. engineers say.

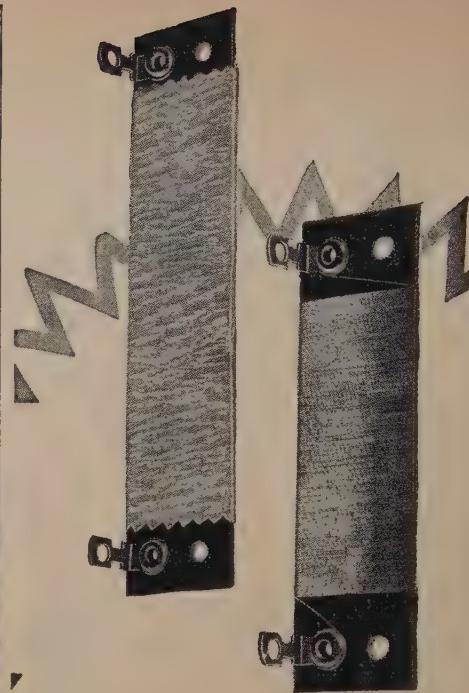


"Broadcasters get an added 'bonus' when using the new circuit and tube," G.E. Engineers explain, "because it simplifies transmitter maintenance and operates with fewer tubes and simpler circuits than pre-war FM transmitters. For the broadcasting technician" they claim, "it permits direct crystal control using a single crystal; modulation is independent of frequency control; it provides better frequency stability, has less distortion and lower noise level; and the circuit is extremely simple."



Sensitive R.F. Voltmeter announced by Ballantine Laboratories, Boonton, N. J. Model 304 is a version of the standard Ballantine Model 300 Electronic Voltmeter, bandwidth the high frequency limit extends to beyond 5 MEGACYCLES. The adoption of the probe type of input connec-

(Continued on page 66A)



Tight-Tolerance RESISTORS

★ Just turn those tight-tolerance resistor requirements of yours over to CLAROSTAT, just as other instrument makers have been doing for years past.

Remember, CLAROSTAT specialists offer over two decades of winding experience, outstanding skill, and exclusive winding facilities. They wind all wire sizes even down to .0009" dia. Windings as fine as 600 to 700 turns per inch, on bakelite, ceramic or other material, flat or round. Also string windings in fibre glass, and cord.

★ Submit your problem . . .

Solving your resistance and control problems is our business. Call on us for engineering collaboration, specifications, quotations.



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The highly efficient output network of the Collins 20K AM broadcast transmitter contributes materially to its high operating economy and reliability. Efficient transfer of power from final amplifier to antenna calls for less power input, and therefore less power dissipation in circuit elements. Lower operating cost, greater dependability, and longer component life are the results of ingenious coordination of circuit design, components, and tubes.

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Complete metering and motor tuning provide control over all circuits. Power change-over from 1000 watts to 500 watts is instantaneous. Write for further information. Collins Radio Company, Cedar Rapids, Iowa; 11 West 42nd Street, New York 18, N. Y.

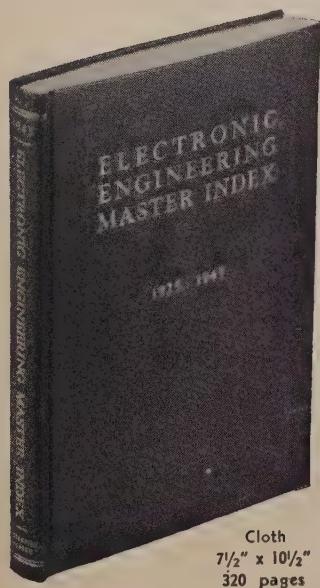


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Bell System Technical Journal	Journal of Applied Physics
Communications	Proceedings of I.R.E.
Electrical Communication	Transactions of A.I.E.E.
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2 W. 46th Street

New York 19, N.Y.

News and New Products

(Continued from page 64A)

tion assures greatest accuracy of indication at radio frequencies.

The instrument to be described is not intended to replace the standard Model 300 Voltmeter. It fulfills the need for a voltmeter capable of indicating millivolts in television and F. M. intermediate frequency amplifier circuits, R.F. heating apparatus, carrier current systems, etc., wherever sensitivity and low shunting error are required. In such applications it provides reliable indications of the voltages to be measured. Due to component limitations, however, it does not possess the remarkable degree of accuracy of its prototype and where its greater frequency range is not required, should not be considered as equivalent.

The circuit bears a strong resemblance to the original Ballantine voltmeter. Once the applied signal has passed through the cathode follower input stage it is impressed across a resistance attenuator, followed by a 3-stage amplifier and diode rectifier which is characterized by the same feedback system as used in the standard Model 300 Voltmeter. The extension of the bandwidth has been accomplished by the use of higher gain tubes and rearrangement of circuit components to reduce high frequency losses.

The output of the amplifier is separately available through a coaxial type connector, hence permitting visual observation of the input wave on an oscilloscope as well as other applications for such a wide band amplifier. The full gain of this amplifier is approximately 500.

Since the design permits of only a 3-step attenuator, the extension of the voltage range above 1 volt requires the use of multipliers. Two such devices are supplied with each voltmeter so that the instrument then provides the same range as the standard Model 300 Voltmeter, namely .001 to 100 volts. The multipliers are compact units which fit snugly over the probe terminals and simply extend the length of the probe by 1½ inches. Additional units will be made available in the future which will further raise the voltage limit. These will also provide progressive reduction of shunting loss as the input capacity becomes less for each upward extension of voltage range.



New-hp-Model 201B AF Oscillator is offered by Hewlett-Packard, Inc., Palo Alto, California. In FM and other fields where high fidelity is important, this new

(Continued on page 69A)

News and New Products

(Continued from page 66A)

-hp- Model 201B Audio Frequency Oscillator is designed to meet every requirement for speed, ease of operation, accuracy and purity of wave form.

The 201B has an accurate, convenient method of frequency control. The 6" dial, with smooth-ball-bearing action, may be tuned by a directly controlled knob, or for still greater accuracy, may be set by the vernier which has a ratio of 6 to 1 to the main dial. The illuminated main dial is designed so that parallax is eliminated. It is calibrated over 300 degrees with approximately 95 calibration points and has an effective scale length of about 47 inches. Frequency range is 20 cps to 20 kc.

Increased Power Output: The amplifier delivers up to 3 watts of power into a 600 ohm resistance load, with distortion held to 1%. Thus there is sufficient power available for driving almost any kind of laboratory or production equipment. Harmonic distortion may be kept to less than $\frac{1}{2}$ of 1%, if the output of the amplifier is limited to 1 watt.

Provision is made for standardizing each frequency range against a reliable standard.

Dual Control for Output Level: A volume control which is ahead of the amplifier controls the voltage at which the amplifier operates. An output attenuator is provided to attenuate the signal delivered by the amplifier. Attenuation is approximately linear from zero to 40 db. Both hum level and output voltage are thus attenuated together. As a result it is claimed that hum level may be kept 60 db, or more below the signal level, a special advantage in cases where small test signals are used.

The impedance looking back into the output circuit is about 50 ohms; thus the voltage regulation for varying loads is extremely good.

Improved chassis layout and placement of component parts minimizes thermal drift. The voltage on the oscillator is maintained constant with an electronic voltage regulator. The entire instrument is characterized by greater rigidity; the tuning assembly is mounted on a sturdy cast aluminum frame. The chassis itself is made of aluminum; the oscillator is light in weight and easy to handle.



New -hp- Model 330B Distortion Analyzer is announced by Hewlett-Packard, Inc., Palo Alto, California. This resistance-tuned circuit is used in conjunction with an

(Continued on page 70A)

**Now available - an
ELECTRONIC
VOLTMETER**

BATTERY OPERATED

THIS MODEL 302

Sensitive Electronic Voltmeter is a new battery operated version of the standard Model 300 A.C. operated voltmeter. Operates from light-weight batteries contained within the carrying case.

MODEL 300
AC operated



Incorporating the popular single logarithmic voltage scale and uniform decibel scale, the Model 302 battery operated instrument retains all of the desirable features and performance of the standard Model 300 AC operated voltmeter illustrated at the left.

**Voltage Range=.001 to 100 volts
Frequency=5 to 150,000 cycles
Accuracy=2% at any point on scale**

The Model 302 Voltmeter will be found useful where A.C. supply is not available, as for example in airplanes, boats, automobiles, in the field, etc. Also valuable for making measurements on ungrounded and symmetrical circuits. Batteries meet JAN specifications.

Send for Bulletin for further description



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News and New Products

(Continued from page 69A)

amplifier to provide many new advantages. The Model 330 B is claimed to be capable of measuring distortion at any frequency between 20 cps and 20,000 cps. It will make noise measurements of voltages as small as 100 microvolts. A linear r-f detector makes it possible to measure these characteristics directly from a modulated r-f carrier. The convenience of operation, high sensitivity, accuracy, stability, and light weight of the 330 B are its designed values for broadcast, laboratory, and production measurements.

In audio work the Model 330B measures distortion at any frequency between 20 cps and 20,000 cps! Thus an instrument which completely covers the audio spectrum is available for "total" distortion measurements.

The circuit of Model 330B consists of a linear r-f detector, a frequency-selective amplifier, a vacuum-tube voltmeter, and regulated power supply.

The voltmeter section of the instrument consists of a two-stage high-gain amplifier, a rectifier, and an indicating meter. A large amount of negative feedback is employed to insure stability and a uniform response from 10 cps to 100,000.

New Sound Pressure Measurement Standard

.... is announced by Massa Laboratories, Inc., 3686 Carnegie Ave., Cleveland 15, Ohio. The Massa Model M 101 Sound Pressure Measurement Standard is claimed to be a precision acoustic instrument developed for making absolute sound pressure measurements throughout the audible frequency range without appreciably disturbing the sound field. The basic ideal requirements of high mechanical impedance, small physical size, wide dynamic range, and flatness of response are the objective of this unit. The vibrating system is stiffness-controlled to well beyond 30 kc, which results in a pressure sensitivity independent of frequency throughout the entire audible range. Its rugged design, and wide dynamic range, makes this standard also usable for the quantitative investigation of extremely high sound pressures, such as are encountered in the measurement of gun-blast waves.

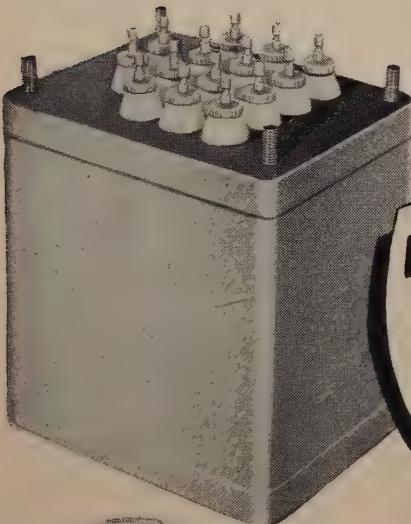
Applications:

The Model M 101 Standard has been developed for all uses where accurate sound pressure measurements are to be made over a wide audio-frequency range. The mechanical system is linear to sound pressures of several million dynes/cm², permitting measurements over an extremely wide dynamic range. In addition to its conventional laboratory use in the calibration of sound fields, the unit is claimed to be ideal for many other types of acoustic measurements.

A technical bulletin is available upon request, giving a more complete description of the new standard.

(Continued on page 72A)

Every
AMERTRAN
TRANSFORMER
is
BUILT
WITH
CARE



**Advantages
 of multiple coil
 winding**



Products:

Audio Transformers and Reactors. Modulation Transformers (to 500 KVA). Hermetically sealed Transformers. Plate and Filament Transformers. Filter Reactors. Wave Filters. High Voltage Rectifiers. Microphone and Interstage Transformers. Transtat A.C. Voltage Regulators. Other Electronic and Industrial Transformers.

Coil winding is an important phase of AmerTran Transformer construction. Use is made of high speed multiple winding machines (some of AmerTran design) capable of producing many coils at a time with exceptional uniformity. Care enters the picture in the precise control with which such elements as number of turns, tightness of layers and wire tension are maintained. Tight coils have fewer and smaller air pockets, and greater heat-conducting capacity. AmerTran coil winding methods add up to close conformity to specifications, uniformly excellent characteristics, and usually a consumer saving for a specific type and quality of transformer.

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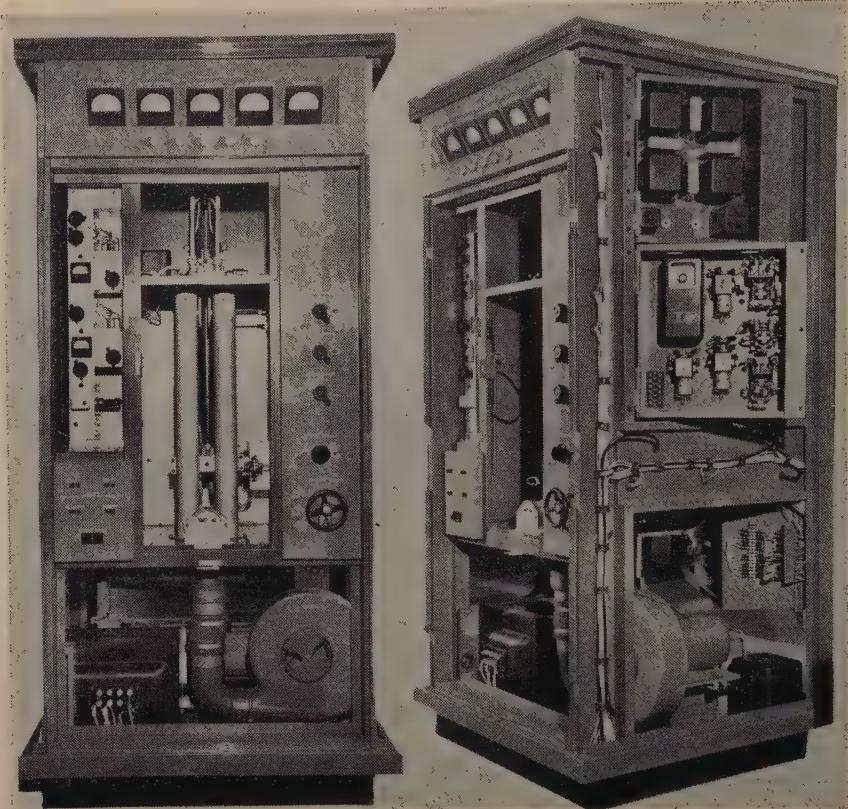
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 Chicago 6

News and New Products

(Continued from page 70A)



Showed at the Sixth Annual Broadcast Engineering Conference

... by Radio Engineering Laboratories, Inc. REL Model 518A-DL 1 KW. FM Broadcast Transmitter, 88/108 mc. left picture is front view with doors and panels removed. Note that all controls and switches are operated from the front of transmitter. Large scale meters are provided in an inclined position for easy reading by operator. The multiplier chassis shown in vertical position at left is the final panel of the Armstrong Dual Channel Direct Crystal Controlled Modulator. This is equipped with quick opening catches and quick opening hinges so that chassis may be swung open for inspection and servicing or entirely removed if necessary. All adjustable tuning controls are provided in the vertical panel at the right. The P.A. grid, P.A. plate, antenna, tuning controls, as well as crystal vernier are equipped with counters for assistance in proper tuning. The Crystal Vernier control enables the operator to adjust to center frequency by reference to a Frequency and Modulation Monitor which is also manufactured by REL. The wheel shown is a Variac con-

trolling all filaments. In the center may be seen the P.A. chamber in which high power is fully isolated from other circuits. Between the P.A. lines, the antenna bazooka can be seen. In the lower right hand corner of the P.A. chamber is located the high frequency vacuum tube volt meter for antenna line RF indication. At the bottom of the cabinet, the blower with connection to plate lines is shown. The blower is claimed to be of more than sufficient size and capacity to provide cooling to all parts of the equipment.

Right side view with doors and panels removed showing large scale meters, front end controls, and switches. Also note that the power controls and power supply located in the right side are on vertical chassis which are hinged, providing complete accessibility of components and chassis wiring. This view also shows main transmitter wiring which runs entirely through vertical and horizontal ducts allowing ease of repair or replacement of connection in the equipment.

FRANK MASSA

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CARBONYL IRON POWDERS AND SOME OF THEIR PRESENT USES

The different grades of CARBONYL IRON POWDERS as seen in the microscope



C Powder



E Powder



TH Powder



SF Powder



"C" Type Powder Enclosed in fiber coils.



For antenna coils, "E" Type Powder used in cores.



TH Type Powder employed for peristatic in coils.



One use of SF Type Powder is in high frequency choke coils with induction tanks.

Table 2 below gives relative Q values (quality factors) and effective permeabilities for the different grades of carbonyl iron powder. The values given in the table are derived from measurements on straight cylindrical cores placed in simple solenoidal coils. Although the

data were not obtained at optimum conditions, the Q values as expressed in percentage of the best core give an indication of the useful frequency ranges for the different powder grades.

"L" and "C" powders are also used as powder metal-

TABLE 2

Carbonyl Iron Grade	Effective Permeability at 1 kc	Relative Quality Factor at				
		10 kc	150 kc	200 kc	1 Mc	100 Mc
L	4.16	100	96	90	43	1
C	3.65	94	100	98	72	3
E	3.09	81	94	100	97	30
TH	2.97	81	93	98	100	54
SF	2.17	62	71	78	84	100

(Note: The actually measured Q values can be obtained by multiplying the rows respectively with: 0.78, 1.09, 1.25, 2.63, and 1.62.)

urgical material because of their low sintering temperatures, high tensile strengths, and other very desirable qualities. (Sintering begins below 500° C and tensile strengths reach 150,000 psi.)

Further information can be obtained from the Special Products Sales Dept., General Aniline & Film Corporation, 270 Park Ave., New York 17, N. Y.

G.A.F. CARBONYL IRON POWDERS



ATLANTA

"Some Notes on Units and Measurement Scales Used in Communication Engineering," by N. B. Fowler, American Telephone and Telegraph Service; November 9, 1945.

"Recent Developments in Sonar," by Frank Lowance, Georgia Institute of Technology; November 30, 1945.

"Atomic Energy," by J. H. Howey, Georgia Institute of Technology; December 28, 1945.

BOSTON

"Microwave Sources for Radar," by A. G. Hill, Massachusetts Institute of Technology; January 4, 1946.

"An Introduction to Loran," by J. A. Pierce, Harvard University; January 18, 1946.

BUFFALO-NIAGARA

"Very-High-Frequency Aircraft Radio Equipment," by R. E. Frazier, J. Chandler, M. C. Scott, and J. C. Pontius, Colonial Radio Corporation; January 16, 1946.

CHICAGO

"Some Aspects of Acoustic-Horn Theory," by Vincent Salmon, Jensen Radio Manufacturing Company; December 21, 1945.

"The Technics of Postwar Television," by A. B. DuMont, Allen-B. DuMont Laboratories; January 10, 1946.

CINCINNATI

"Microwave Television-Relay Networks," by H. B. Francher, General Electric Company; December 18, 1945.

Election of Officers; December 18, 1945.

"Quality in Sound," by J. D. Reid, The Crosley Corporation; January 15, 1946.

"The Electronic Organ," by J. F. Jordan, The Baldwin Company; January 15, 1946.

CLEVELAND

"Short-Wave Diathermy Apparatus and Frequency-Control Possibilities," C. K. Gieringer, Liebel-Flarsheim Company; January 24, 1946.

CONNECTICUT VALLEY

"Record Embossing," by Lincoln Thompson, Soundscriber Corporation; October 18, 1945.

"Klystrons," by A. E. Harrison, Sperry Gyroscope Company; December 13, 1945.

"Microwave Relay Systems," by H. B. Francher, General Electric Company; January 8, 1946.

DALLAS-FT. WORTH

"VHF Field Intensity Survey—Summer 1945," by J. G. Rountree, Federal Communications Commission; January 17, 1946.

Election of Officers; January 17, 1946.
(Continued on page 38A)



What you should know about the SHURE *Glider* Phonograph Pickup

What is the "Glider" Pickup?	The "Glider" Pickup is a lightweight, low mass Tone Arm with the new Shure Lever-Type Crystal Cartridge.
How is low mass achieved?	The arm is aluminum. It uses no counterweights or springs. It has a needle force of only 1½ ounces.
What is meant by Lever-Type Cartridge?	The Crystal is driven by a lever which improves the transmission of needle chuck torque into the Crystal. This results in higher output and greater lateral needle point compliance. It absorbs full impact of sudden jars to the Cartridge or needle, minimizing Crystal strain or breakage.
What is its output voltage?	The various types range from 1.6 volts to over 3 volts.
What are its playing qualities?	High needle point compliance affords faithful tracking which results in clearer, fuller tone qualities. Lightness means longer record life. The "Glider" is less susceptible to floor vibrations, improves playing of warped records and is especially suitable for Viny-lite records.

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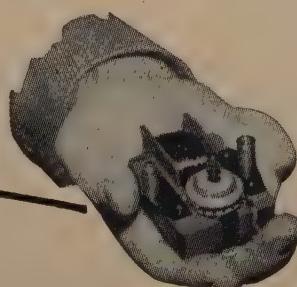


ALLIANCE MOTORS are made with centerless ground precision shafts; large, self-aligning, graphite bronze oilless-type bearings; and with adequate mounting facilities to incorporate them in any device. Shaded pole induction type motors for A.C. voltage from 24 to 250, and frequencies of 40, 50 or 60 cycles have starting torques from one-half ounce inches at 10 watts, to two ounce inches at 36 watt input. Split phase resistor type, enclosed reversible control motors for intermittent duty, with or without integral gear reduction are made for 60 cycles, 24 or 117 volts. Typical weights run from less than 13 ounces to more than two and one-half pounds.

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Electronic and electric controls, time, pressure, temperature, pressure and humidity controls, remote actuation controls, radio tuning and turntable drives, coin operated dispensers, fans, valves, blowers, door openers, signals, motion displays, projectors and specialized uses.

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With Alliance Powr-Pakt miniature electric motors you can put power right where you need it! Electronic controls and electro-mechanical devices will work faster, you cut down manual effort and increase automatic operation.

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Remember, there's probably an Alliance motor already designed and ready to go to work for you!

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STANDARD TRANSFORMER CORPORATION
1500 NORTH HALSTED STREET CHICAGO 22, ILLINOIS

SECTION MEETINGS

(Continued from page 36A)

DAYTON

"Electronic Aspects of the Geiger-Mueller Counter Tube and Spectrometer," by D. H. Reynolds and J. W. Heyd, Monsanto Chemical Company; January 16, 1946.

DETROIT

"New Things to Come," by H. S. Walker, The Detroit Edison Company; January 18, 1946.

EMPORIUM

"Notes on a Trip to England," by M. G. Hasselman, Sylvania Electric Products; January 14, 1946.

"The Principles of Cathode-Ray-Tube Operation," by W. A. Dickinson, Sylvania Electric Products; January 14, 1946.

INDIANAPOLIS

"Development of Voltage Regulators," by C. H. Humes, Solar Electric Company; November 23, 1945.

"The New Radio-Frequency Ignition System," by A. C. Wall, P. R. Mallory Company; November 23, 1945.

"New Frequency-Control System," by J. R. Boykin, Westinghouse Electric Corporation; December 28, 1945.

MONTRÉAL

"Radar in World War II," by K. R. Patrick, RCA Victor Company; December 12, 1945.

PHILADELPHIA

"Television-Receiver Testing in Production," by J. A. Bauer, RCA Victor Division; January 11, 1946.

PITTSBURGH

"Magnetic-Tape Recording," by L. A. Umbach, Carnegie Institute of Technology; January 14, 1946.

"Working with Microwaves," by R. G. Plaisted and S. A. Leiner, University of Pittsburgh, January 14, 1946.

PORTLAND

"Civil Aeronautics Administration Radio Range, As Used for Air Navigation," by W. A. Cutting, Portland Interstate Airways Communications; December 21, 1945.

Election of Officers; December 21, 1945.

ROCHESTER

"Transmutation of the Elements," by K. K. Darrow, Bell Telephone Laboratories; January 10, 1946.

SAN DIEGO

"The Phasitron as Used in Frequency Modulation," by C. G. Pierce, General Electric Company; January 4, 1946.

Election of Officers; January 4, 1946.

SEATTLE

"Atomic Bombs and the Hanford Project," by F. T. Matthais, Hanford Engineering Works; December 17, 1945.

Election of Officers; December 17, 1945.

(Continued on page 40A)

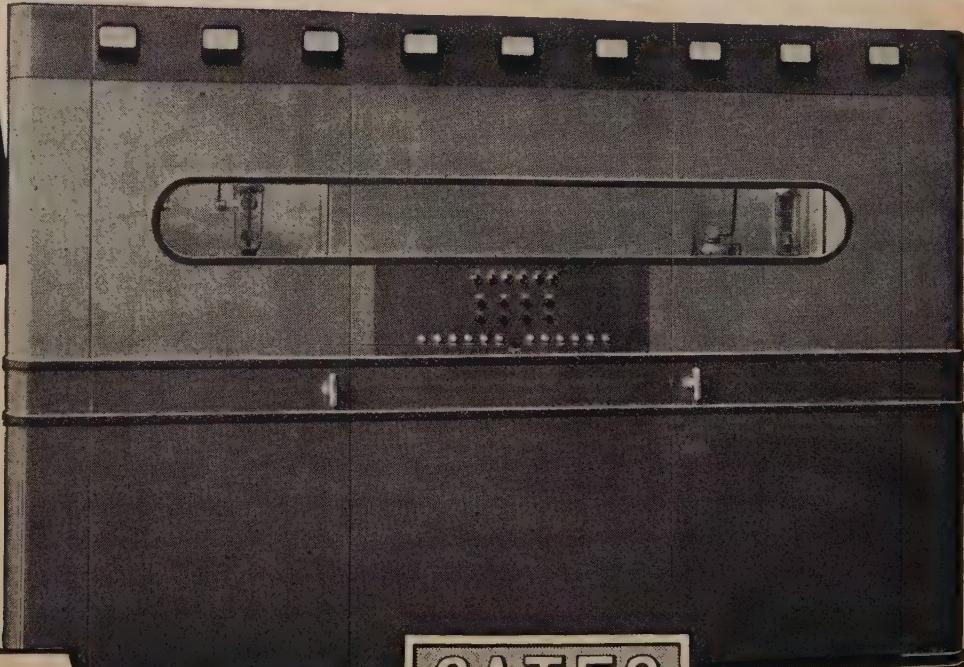


GOOD NEWS!

for RADIO STATION ENGINEERS...MANAGERS

...and for those who plan a "Dream Station"

SOON
AVAILABLE



NOTE THESE SPECIFICATIONS

Carrier Frequency	Plus or minus 10 cycles
Stability	maximum.
Audio Distortion	Less than 3%, 95% modulation, 50 to 7500 cycles.
Audio Frequency Response	Plus or minus 1½ Db., 30 to 10,000 cycles.
Carrier and Hum Level	Better than 60 Db. below 100% modulation, unweighted.
Power Supply	230 volts, 3 phase, 60 cycles.

GATES

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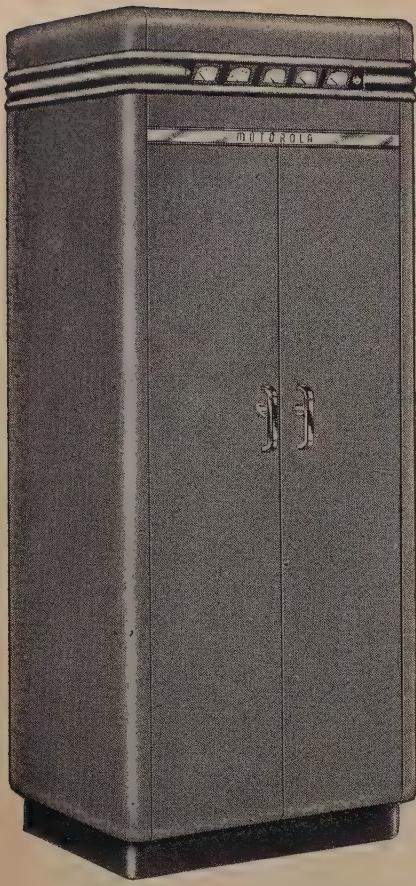
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Illustrated is Motorola's newest contribution to this field—the Model FSTRU-250-BR 250-watt Central Station Transmitter - Receiver Unit, designed for the newly-established 152-162 mc. band.

POLICE USE *Motorola*

Eighty percent of all FM Police radio equipment in use today is Motorola. This includes a roster of 35 state police systems and many thousands of city and county systems throughout the United States.



• • • • •
WRITE FOR
ANDREW CATALOGUE
TODAY



(Continued from page 38A)

TWIN CITIES

"Scientific Developments in Germany," by W. H. Gille, Minneapolis-Honeywell Regulator Company; January 15, 1946.

WILLIAMSPORT

"Transcontinental Tour," by H. R. Traver, Sylvania Electric Products; January 15, 1946.

"Some Wartime Microwave Tube Developments," by William Hannahs, Sylvania Electric Products; January 15, 1946.

SUBSECTIONS

COLUMBUS

"Radar in the U. S. Army," by W. L. Everitt, University of Illinois; December 6, 1945.

"Electromagnetic Theory Without Mathematics," by R. H. Nelson, Ohio State University, January 11, 1946.

MILWAUKEE

"The Behavior of Dielectrics Over Wide Range of Frequencies, Temperature, and Humidity," by R. F. Field, General Radio Company; September 26, 1945.

"Application of Radar," by W. L. Everitt, University of Illinois; November 28, 1945.

PRINCETON

"Television—Where it is and Where it is Going," by R. M. Kell, RCA Laboratories; January 16, 1946.



The following transfers and admissions were approved on February 5, 1946:

Transfer to Senior Member

Abbott, N. A., 2327—25 St., S. E., Washington 20, D. C.

Anthes, R. G., 506 Donlands Ave., Toronto 6, Ont., Canada

Bozzoli, G. R., Witwatersrand University, Department of Electrical Engineering, Johannesburg, South Africa

Brophy, R. M., Rogers Majestic Ltd., 622 Fleet St. W., Toronto 2B, Ont., Canada

Crane, W. K., 4000 Mountain View Dr., Bremerton, Wash.

Finnigan, C. W., Stromberg-Carlson Company, 100 Carlson Rd., Rochester 3, N. Y.

Fischer, F. W., 714 Beechfield Ave., Baltimore 29, Md.

Heffelfinger, J. B., 815 E. 83 St., City 5, Mo.

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(Continued on page 42A)



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BUT NOT ON YOUR PAYROLL

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**When you buy Electrical
Insulation you should get
Materials Plus Service ...**

The IMC engineer is, in effect, traveling companion to IMC products. He is ready at all times to ...

1. Assist you in the selection of the best insulating material for the job.
2. Familiarize you with their proper application.
3. Suggest ways to eliminate waste.
4. Increase your production.

His is "experience at work" to insure insulation that approaches perfection. It is due in large measure to the wholehearted co-operation of IMC engineers that IMC materials are favorably known and so widely used.



EVERYTHING FROM ONE SOURCE

A complete insulation service from one source gives time-saving advantages to you.



NATIONALLY RECOGNIZED PRODUCTS

The highest quality products made to rigid specifications guarantee you top notch performance of your product.



TAILOR-MADE TO YOUR NEEDS

If you desire, we have the facilities to fabricate parts to your specifications.



"KNOW HOW" ENGINEERS...STRATEGICALLY LOCATED

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PROMPT SHIPMENT FROM COMPLETE STOCKS

Products are quickly on the way to you by truck, freight, mail, or express.

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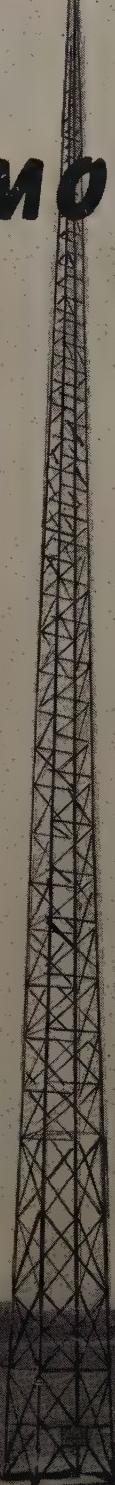
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If you're planning to add load to your output, you can take a load off your shoulders by turning your antenna problem over to Blaw-Knox.

Unequalled experience in this field—backed by thousands of successful installations ranging in size up to 1000 feet—means that you can rely on Blaw-Knox for full responsibility in the fabrication and erection of complete antenna systems.

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(Continued on page 44A)



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625-N

LONG SCALE, WIDE RANGE VOLT-OHM-MILLIAMMETER

DOUBLE SENSITIVITY D. C. VOLT RANGES

0-1.25-5-25-125-500-2500 Volts,
at 20,000 ohms per volt for greater accuracy on
Television and other high resistance D.C. circuits.
0-2.5-10-50-250-1000-5000 Volts,
at 10,000 ohms per volt.

A. C. VOLT RANGES

0-2.5-10-50-250-1000-5000 Volts,
at 10,000 ohms per volt.

OHM-MEGOHMS

0-400 ohms (60 ohms center scale)
0-50,000 ohms (300 ohms center scale)
0-10 megohms (60,000 ohms center scale)

DIRECT READING OUTPUT LEVEL DECIBEL RANGES

-30 to +3, +15, +29, +43, +55, +69 DB

TEMPERATURE COMPENSATED CIRCUIT FOR
ALL CURRENT RANGES D.C. MICROAMPERES
0-50 Microamperes, at 250 M.V.

D. C. MILLIAMPERES

0-1-10-100-1000 Milliamperes, at 250 M.V.

D. C. AMPERES

0-10 Amperes, at 250 M.V.

OUTPUT READINGS

Condenser in series with A.C. Volts for output
readings.

ATTRACTIVE COMPACT CASE

Size: 2½" x 5½" x 6". A readily portable, completely
insulated, black, molded case, with strap handle.
A suitable black, leather carrying case (No. 629)
also available, with strap handle.

LONG 5" SCALE ARC

For greater reading accuracy on the Triplett
RED • DOT Lifetime Guaranteed meter.

SIMPLIFIED SWITCHING CIRCUIT

Greater ease in changing ranges.

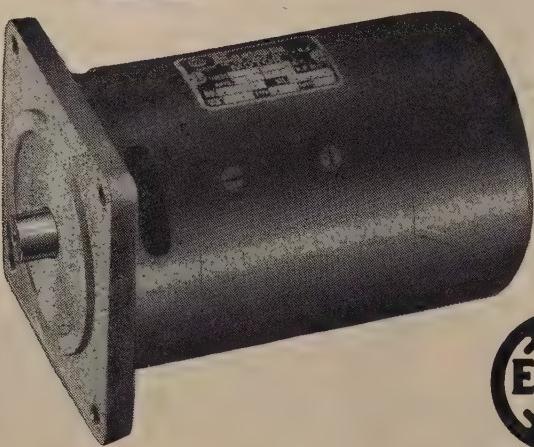
Write for descriptive folder giving full technical details

Precision first
...to last

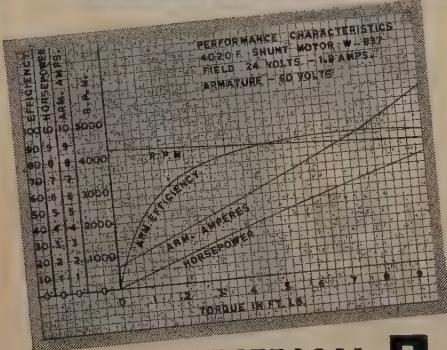
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ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO





4000 FRAME MOTOR 1/2 HP at 3900 RPM



ELECTRICAL
Series, shunt, or compound-wound
Unidirectional or reversible
Optional torque
Optional speed
Optimum efficiency
For control circuits
Electric braking optional

FEATURES

MECHANICAL
Ventilated or enclosed types
Base or flange mounting
Operation in any position
Low space factor
Ball bearing equipped
Optional shaft details
Rugged construction

4000 FRAME MOTORS		4020 Shunt	4020 Series
Watts, Output, Con.	(Max.)	375	746
Torque at 3900 RPM	(ft. lbs.)	.65	1.4
Torque at 6000 RPM	(ft. lbs.)		.88
Speed Regulation		8%	
Lock Torque	(ft. lbs.)	2.5	4
Volts Input	(min.)	12	24
Volts Input	(max.)	110	110
Diameter		4"	4"
Length Less Shaft		7 1/8"	7 1/8"
Shaft Dia.	(max.)	.625"	.625"
Weight	(lbs.)	9.2	9.2

EICOR INC. 1501 W. Congress St., Chicago, U.S.A.
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Cambridge, Mass.
Ryan, C. E., 911 Garland St., Tacoma
Park, Md.
Scheuch, D. R., Radio Research Laboratory,
Harvard University, Cambridge
38, Mass.
Schmeisser, K. R., 13117 LaSalle Blvd.,
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Blackwell, R. F., 31 Ellenbrook Lane, Hatfield, Herts., England
Boutz, F. E., 878-4 St., Crescent City, Calif.
Brackmann, W. J., Bell Telephone Laboratories, 180 Varick St., New York, N. Y.
Breeden, F. C., Sylvania Electric Products Inc., 34-10 Linden Pl., Flushing, N. Y.
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(Continued on page 46A)

MYKROY
PERFECTED MICA CERAMIC INSULATION

DOESN'T CARBONIZE!



This high frequency insulation will not carbonize under arc, yet it possesses dielectric properties of the highest order. Made entirely of inorganic materials, Mykroy cannot char or turn to carbon even when exposed to continuous arcs and flashovers.

The sheet of Mykroy in the photo was exposed to a 50,000 volt arc after which it was sectioned and carefully examined for signs of damage. None were found . . . not even the slightest excoriations were present, hence no low resistance paths formed to support breakdown.

Engineers everywhere are turning more and more to Mykroy because the electrical characteristics of this perfected glass-bonded ceramic are of the highest order—and do not shift under any conditions short of actual destruction of the material itself. Furthermore Mykroy will not warp—holds its form permanently—molds to critical dimensions and is impervious to gas, oil and water. For more efficient insulation investigate Mykroy. Write for copies of the latest Mykroy Bulletins.

Cross sections of the test sheet made at the point of exposure to the 50,000 volt arc (magnified 10 times) show no trace of damage.

MECHANICAL PROPERTIES*

MODULUS OF RUPTURE.....	18000-21000 psi
HARDNESS.....	

Mohs Scale 3-4 BHN. BHN 500 K9 Load. 63-74	
IMPACT STRENGTH.....ASTM Charpy .34-.41 ft. lbs.	
COMPRESSION STRENGTH.....	42000 psi
SPECIFIC GRAVITY.....	2.75-3.8
THERMAL EXPANSION.....000006 per Degree Fahr.	
APPEARANCE.....	Brownish Grey to Light Tan

ELECTRICAL PROPERTIES*

DIELECTRIC CONSTANT.....	6.5-7
DIELECTRIC STRENGTH (1/8").....	630 Volts per Mil

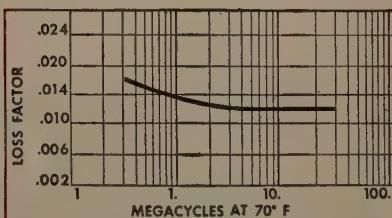
POWER FACTOR.....001-.002 (Meets AWS L-4)

*THESE VALUES COVER THE VARIOUS
GRADES OF MYKROY

GRADE 8 Best for low loss requirements.
GRADE 38 Best for low loss combined with high mechanical strength.

GRADE 51 Best for molding applications.

Special formulas compounded for special requirements.



Based on Power Factor Measurements made by Boonton Radio Corp. on standard Mykroy stock.

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MYKROY IS SUPPLIED IN SHEETS AND RODS — MACHINED OR MOLDED TO SPECIFICATIONS

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SMALL
like the
LARGE...



in Vertical **FULLY MOUNTED** **TRANSFORMERS**

FIVE newly-developed vertical shields, accommodating core stacks with $\frac{1}{2}$ " to $\frac{7}{8}$ " center legs, now make it possible for Chicago Transformer to fully-mount both small and large transformers with uniformity.

Now, in radio chassis and similar applications, both small and large units can be vertically-mounted with standardized assembly techniques—with uniform appearance in the finished product.

Adaptable to many variations, Chicago Transformer's complete line of vertical shields allows for either screw or twist-lug mountings and for lead exits through either sides or bottoms of the shields.

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Lafferty, J. M., Research Laboratory, General Electric Company, Schenectady, N. Y.

Lathrop, R. E., 907 Racine Ave., Waukesha, Wis.

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Yeh, B., 404 W. 115 St., New York, N. Y.

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(Continued on page 48A)



Flight engineered for performance and dependability

"replaced cathode bias resistor 'reference No. 508' with a 400 ohm 2 watt resistor."

. . . an excerpt from a typical Bendix Radio Flight Engineers report. A report that means the installed Bendix Radio Communication or Navigation System will meet the equipment user's field operation expectations—laboratory performance and dependability under all conditions.

But—this is only one phase of Bendix Flight Engineering Service. Previous to the equipment's purchase highly skilled Bendix engineers make a comprehensive field survey that is intended to aid in planning the installation to the user's satisfaction. This survey provides Bendix with equipment modification data and aids in the creative engineering of any new design products needed for this installation.

Planned for the user, Bendix Radio Flight Engineering Service enables him to realize the greatest possible return from his investment—to relieve his mind of worries over proper circuit protection, undesired lock-up of electrical control circuits, radio compass bearing errors, calibration of indicators, etc.

In addition, Bendix Radio provides a Field Engi-

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Developed by Bendix Radio—these Flight Engineering Services are some of the reasons why thousands of users have made Bendix Radio equipment "Standard for the Aviation Industry."

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(Continued on page 52A)



Federal's NEW GROUND STATION TRANSMITTER

FOR GROUND-TO-PLANE AND
POINT-TO-POINT COMMUNICATION

Featuring Dependability — Flexibility
Minimum Maintenance — Maximum Accessibility

Providing the ultimate in dependability and flexibility . . . the FTR type 184 was developed by Federal to meet present day requirements for aviation communications.

Available in various combinations of radio frequency units, power supplies, modulators and auxiliaries for operation by either local or remote control . . . this advanced design transmitter can be supplied to operate at high frequency (2 to 20 mcs.); VHF (108 to 140 mcs.) and at low frequency (200 to 525 kc.) for voice and CW transmission . . .



with outputs ranging from 200 to 500 watts.

Built into this equipment are features that make for simplicity of installation, reliability in operation, accessibility to all interior parts for servicing and maintenance . . . all the result of Federal's notable design technique in transmitters ranging from 2 watts to 200 KW.

Investigate this latest contribution by Federal to dependable aircraft operations . . . and for the finest in ground communication and air traffic control equipment . . . always specify Federal.



Federal Telephone and Radio Corporation

Export Distributor:
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Newark 1, N. J.

NEW

SENSITIVE R-F VOLTMETER

and

Wide Band Amplifier

MODEL 304



RANGE—

.001 to 100 volts

FREQUENCY—

30 c.p.s. to 5.5 Megacycles, ± 0.5 DB

INPUT IMPEDANCE—

1 Megohm shunted by 9 mmfds.

Probe method of connection provides true indication of voltages at point of origin. Logarithmic output meter yields simplicity and accuracy of readings as demonstrated by our voltmeter line for over ten years. Illuminated scale is further aid to observation.

A-C output connector and change-over switch affords separate wide-band amplifier capable of many uses. *Example:* extends useful range of ordinary oscilloscopes to beyond 5 megacycles.

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(Continued on page 58A)

THE NEW RCA SINGLE-RIBBON MICROPHONE

... quickly adjustable to any pickup pattern you want



THIS Multi-Purpose, Polydirectional Microphone (Type 77-D) will help you add even greater balance, clarity, naturalness, and selectivity to your studio pickups.

By means of a continuously variable screw adjustment, located at the back of the microphone, an infinite number of pickup response patterns can be obtained—unidirectional, all variations of bidirectional, and non-directional. Undesired sound reflections can be quickly eliminated merely by switching to a more suitable pattern.

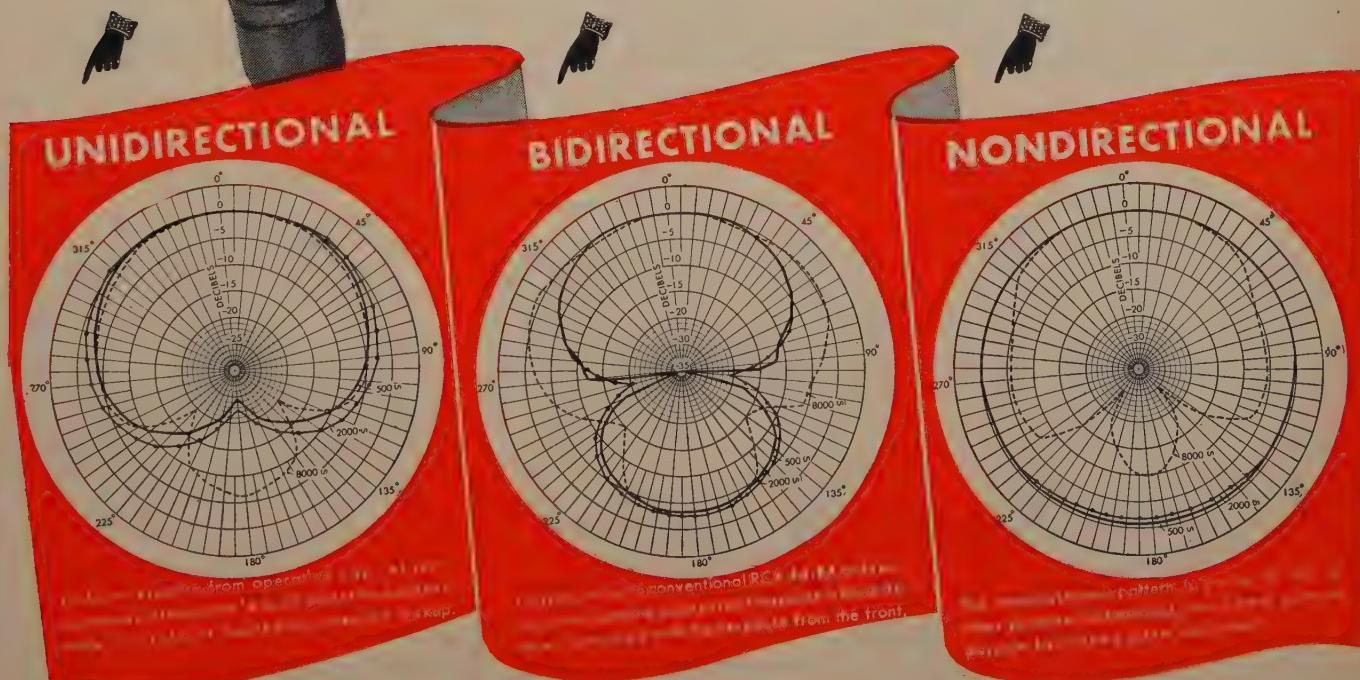
A three-position VOICE-MUSIC switch on the bottom of the microphone is available for changing the low-frequency response, thus per-

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A unique single-ribbon unit combines the performance of the velocity-operated and the pressure-operated units used in previous designs.

Other outstanding features: excellent frequency response, uniform directivity at all frequencies, shielded output transformer, shock mounting, spring-type cord guard, lightweight, small size, and an attractively styled umber-gray and chrome housing.

A bulletin completely describing this outstanding microphone is yours for the asking. Write: Radio Corporation of America, Dept. 67-C, Broadcast Equipment Section, Camden, N. J.



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RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DIVISION, CAMDEN, N. J.



~~POSITIONS OPEN~~

The following positions of interest to I.R.E. members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No.

The Institute reserves the right to refuse any announcement without giving a reason for the refusal.

PROCEEDINGS of the I.R.E. 330 West 42nd Street, New York 18, N.Y.

SENIOR ENGINEER

Newly formed organization for manufacture of radio receiver sets requires experienced man to assume charge of production and general development. Must be able to lay out, set up, and properly equip modern assembly line. New plant in New York area. Excellent opportunity for permanent connection. All inquiries treated confidential. Box 409.

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ENGINEERS

Seniors for design work on radio receivers, audio amplifiers, television

Men with substantial commercial experience wanted, preferably those having Degrees in Electrical or Communications Engineering. Also Mechanical Engineer with knowledge of radio set design to supervise drafting and specifications. Write, giving details of experience and salary expected, to:

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To design and develop production test equipment and fixture used to check R.F. coils and condensers. Knowledge and experience on design of electronic test equipment essential and some radar experience desirable. Salary open. Location Newark. Box 412.

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Prominent Eastern radio set manufacturer requires assistant chief engineer to take complete charge of laboratory. Must be thoroughly competent in AM and FM receiver design; also television; and possess executive ability. Excellent salary and good future. Write complete qualifications and background. Box 408.

~~POSITIONS OPEN~~

TECHNICAL EDITOR

Skilled in servicing electronic equipment, to assist in writing and editing articles about radio repairing. Radio Maintenance Magazine, 295 Broadway, New York 7, N.Y.

SALES ENGINEER

Graduate electrical engineer to apply and sell small fractional horsepower motors to industry. Work direct from sales office of established manufacturer in Rochester, N.Y. Manufacturer's representatives not considered. State fully education, experience, age, and salary expected. Box 322, Rochester 2, N.Y.

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For design and development of home radio receivers. Can use men with experience in design laboratories on communications and entertainment receiving sets. Call or write Mr. Frank A. Hinners, Vice President in Charge of Engineering, Air King Products, 1523 63rd St., Brooklyn 19, N.Y.

APPLIED PHYSICISTS, COMMUNICATION AND ELECTRONICS ENGINEERS

Research minded with good theoretical background to engage in research in aeronautical science, advanced degrees preferred. Salary commensurate with qualifications. Address replies to Cornell Aeronautical Laboratory, Personnel Office, Box 56, Buffalo 5, N.Y. Replies will be held in strict confidence.

ACOUSTICAL ENGINEER

Primarily in the field of architectural acoustics, who is qualified to determine the acoustical properties of broadcasting and recording studios and to develop new methods and equipment for the measurement of these characteristics. A working knowledge of the acoustical problems associated with microphones and loudspeakers is also necessary.

Applications and requests for interviews should be made in writing to W. B. Lodge, Director of Engineering, Columbia Broadcasting System, Inc., New York 22, N.Y.

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Research Engineers with thorough experience in electronics, and micro-wave development. Salary \$5,000 to \$6,000.

Write qualifications to Boyd King, 10 Rockefeller Plaza, New York 20, N.Y.

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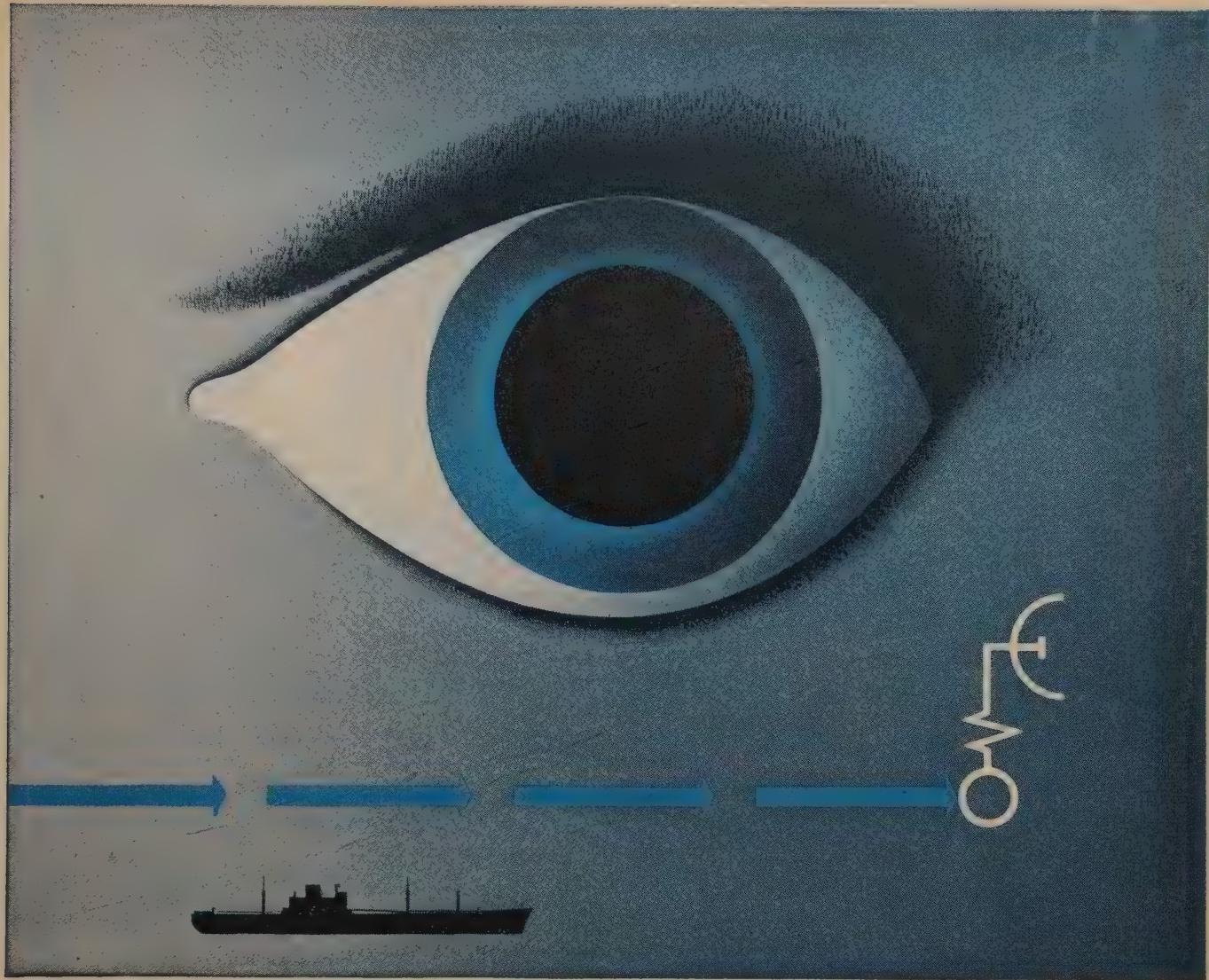
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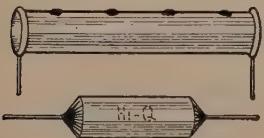
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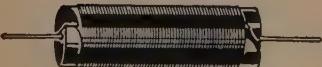
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The Institute publishes free of charge notices of positions wanted by I.R.E. members who are now in the Service or have received an honorable discharge within a period of one year. Such notices should not have more than five lines. They may be inserted only after a lapse of one month or more following a previous insertion, and the maximum number of insertions is three per year. The Institute necessarily reserves the right to decline any announcement without assignment of reason.

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Lerner, S., 469 Burrows Ave., Winnipeg, Manit., Canada
Luno, P., 235½ Egerton St., London, Ont., Canada
Martin, J. G., Calle del Barco No. 31, Madrid, Spain
Masson, F. Y., 340 Cleveland St., Orange, N. J.
McBride, J. D., CFOR, Orillia, Ont., Canada
McCarthy, J. E., Box 382, Barnesville, Minn.
McCauley, A. R., Suydam Lane, Bayport, L. I., N. Y.
McClelland, A. B., 1189 Commonwealth Ave., Allston 34, Mass.
McDonald, D. J., Bell Telephone Company of Canada, Beaver Hall Bldg., Montreal 1, Que., Canada
McIntire, G. W., Box 663, Hagerstown, Md.
McKie, W. M., 77 Hallam St., Toronto, Ont., Canada
Malan, D. G., Box 8718 Johannesburg, South Africa
Meinema, H., 216 N. Harvey St., Oak Park, Ill.
Mestery, S., 294 Fountain St., Winnipeg, Manit., Canada
Michael, F. R., 2125 St. James Pl., Philadelphia 3, Pa.
Miller, B. J., National Bureau of Standards, Washington 8, D. C.
Miller, L. H., 663 Yale St., Akron 11, Ohio
Miller, T. W., 184 Truman Ave., Yonkers 2, N. Y.
Mills, G. J., 405 Winchester St., St. James, Winnipeg, Manit., Canada
Mitchell, W. J., Jr., 1815 S. 55 St., Philadelphia 43, Pa.
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Mullaney, F. C., 1328-A Seminary St., Key West, Fla.
Murphy, J. L., 5810 Adeleine St., Oakland, Calif.
Murray, H. J., Jr., 425 W. 118 St., New York 27, N. Y.
Myers, S. F., 247 Western Ave., Albany, N. Y.
Natman, P. W., 4221—48 St., San Diego 5, Calif.
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(Continued on page 60A)

*new PN cartridges**
for special applications



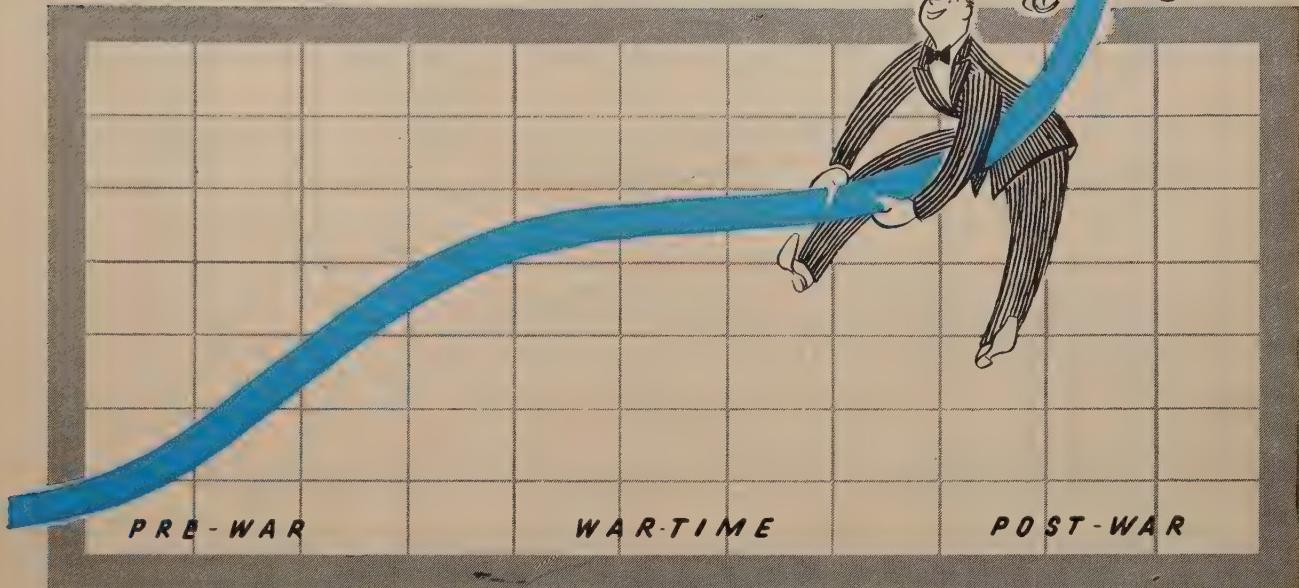
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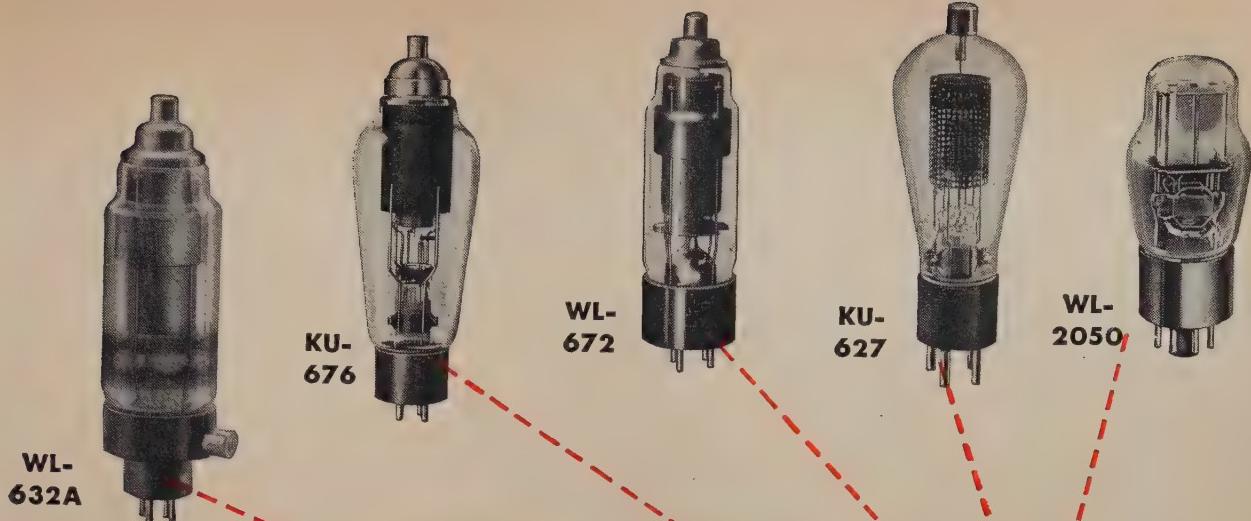
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Shary, R. F., 306 E. 207 St., Bronx 67, N. Y.

(Continued on page 62A)



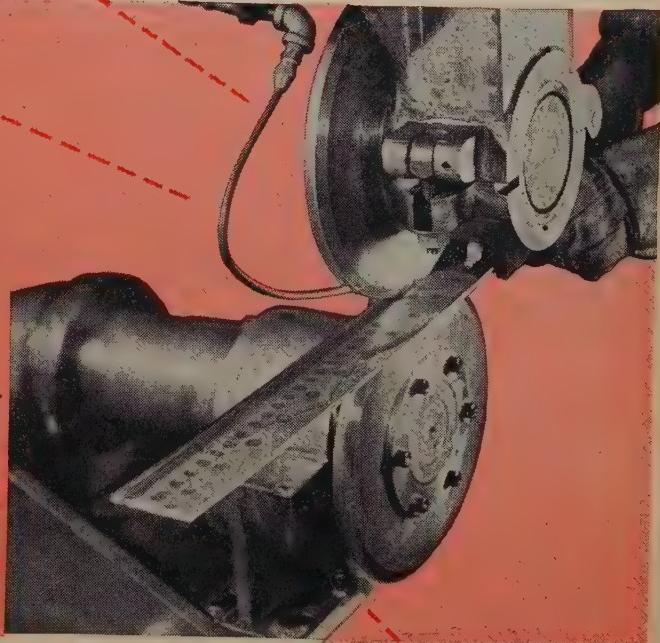
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(Continued from page 60A)

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Winnik, E., 255 Machray Ave., Winnipeg, Manit., Canada

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Wolfson, N., 1375 Ocean Ave., Brooklyn 30, N. Y.

Yorke, C. J., 24 Rattle St., London, Ont., Canada

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Rigid, 3-post deck suspension; double-grip contacts, silver to silver; ball bearing indexing with beryllium copper spring; lugs staked for extra strength.

14 or 20 positions in same space generally required for 12 positions. Often eliminates need for other switches or extra decks.

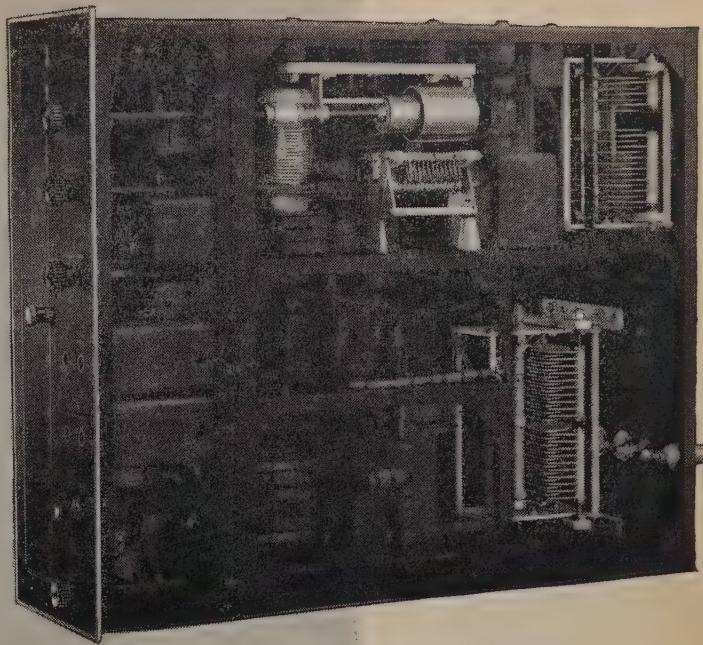
Many variations, such as multiple circuits per deck; four-pole, double-throw band selectors; unusual contact arrangements; non-standard stops and panel locators are being supplied on substantial quantity runs.

J-B-T INSTRUMENTS, INC.

423 CHAPEL STREET • NEW HAVEN 8, CONNECTICUT

Adaptability

... JOHNSON
COMPONENTS PICKED
FOR USE IN AIRLINE
TRANSMITTER !



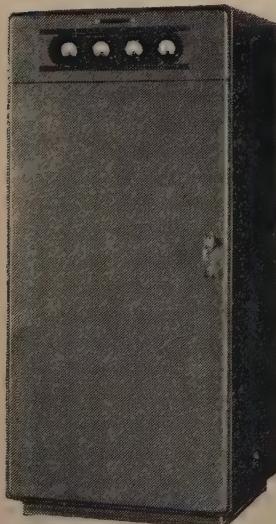
The new Wilcox 99A, medium power, transmitter designed primarily for airline fixed communication service, is provided with features including four removable radio frequency channels in the low, high and very high frequency ranges.

Shown above is one of the r.f. channels with Johnson components highlighted . . . Type D dual condensers in the antenna tuning and final amplifier stages, Type F condenser in the r.f. amplifier, cone insulators and thru-panel insulators with jack connections. None visible in the photograph are Johnson 211 and 237 tube sockets, lead-in bushings and panel bearings.

The use of Johnson components in the Wilcox 99A is further proof of the reliability of Johnson products. In a transmitter of this type, designed for flexible and trouble-free service, components must meet the highest standards of quality and adaptability.

The adaptability of Johnson products results in great savings to Johnson customers by minimizing the need for specially designed components. For example, the Type D dual condensers used in the assembly shown above are standard models reduced in overall size and supplied with special mounting brackets to meet chassis design. The standard Type D used in the final amplifier has been furnished with dual sections of different capacitances, thus eliminating the need for a special condenser.

Whether you are working on a "ham rig," electronic heating equipment, commercial transmitter or any other radio electronic device, you will be sure of top performance with components by Johnson. Send us your special problems and we will first try to adapt our standard products to meet your special requirements.



WILCOX 99A
TRANSMITTER

R. F. CAPACITORS AND INDUCTORS • TUBE SOCKETS • INSULATORS
CONNECTORS • PILOT LIGHTS • HARDWARE ITEMS

WRITE FOR SPECIFIC INFORMATION
OR GENERAL PRODUCTS CATALOG 968A

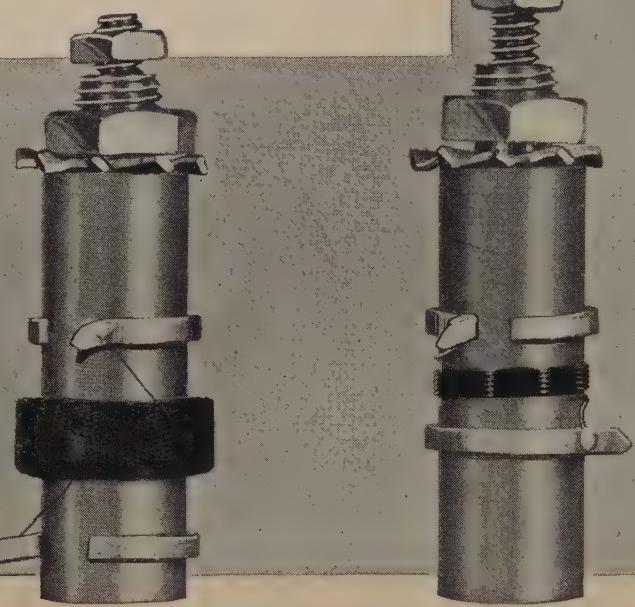
JOHNSON
a famous name in Radio

E. F. JOHNSON COMPANY • WASECA • MINNESOTA

News and New Products

(Continued from page 68)

Try C.T.C.'s New IF SLUG TUNED INDUCTOR COIL



With a frequency range from $\frac{1}{2}$ megacycle to 60 megacycles and a slug tuning range from 1.5-1 in frequency, this tiny, compact LS-3 is ideal for many applications.

Be sure to specify the inductance or capacitance and frequency required when ordering the LS-3.

Write for C.T.C. Catalog No. 100.

CAMBRIDGE THERMIONIC CORPORATION

456 Concord Avenue • Cambridge 38, Mass.



for installation at the Brooklyn plant during the next few months will step up photoflash production to more than double that of the highest pre-war year. Mr. Parker predicted that sales throughout the industry during 1946 would shatter all previous records, with consumption of 60,000,000 flash bulbs.

With acquisition of Wabash and that of Colonial Radio last year, Sylvania has taken its position as a producer in the incandescent lamp, fluorescent lighting, radio tube and photoflash fields, with factories in Massachusetts, Pennsylvania, New York and Illinois, in addition to the Brooklyn plant being acquired. Don G. Mitchell, Vice-President in charge of Sales, Sylvania Electric Products, Inc., places light conditioning and fluorescent lighting at the head of his company's enlarged program for 1946.

Type 706 Thermocouple-Ionization Gauge Control

Manufactured by The National Research Corp., 100 Brookline Ave., Boston 15, Mass.

Type 706 Thermocouple-Ionization Gauge Control is a unit which incorporates circuits for use with any standard ionization gauge, complete with power supply. It is claimed that using National Research Corporation Type 507 Ionization Gauge, which is standard equipment with the control, the range of vacuum measurement from 1 mm. to 2×10^{-7} mm. of mercury is covered. The Thermocouple Gauge handles pressures from 1 mm. to 10^{-8} mm. of mercury. The sensitivity of the Ionization Gauge may be doubled by doubling the grid current. Readings of the Ionization Gauge range are spread by a multiplying switch to indicate full scale meter deflection for 5, 1, 0.1 or 0.01 microns when used with Type 507 Ionization Gauge.

Features include a production-tested Thermocouple Gauge circuit and an Ionization Gauge circuit with outgassing provision, interlocking relay for protection, zero set and zero adjust controls for amplifier balancing.

The cabinet is finished in gray wrinkle paint with black and chrome trim and is ruggedly constructed so that the panel and chassis may be removed from the box and inserted as a unit in a larger control panel.

Carboloy Contacts in Telegraph Relays Reported to Outlast Former Types

It is claimed that electrical contacts made of Carboloy cemented carbide are

(Continued on page 82)

PATTERSON PHOSPHORS ARE AVAILABLE
IN A WIDE RANGE OF

- | | |
|---------------|------------------------|
| 1. Colors | 4. Types of Excitation |
| 2. Grain Size | 5. Afterglow |
| 3. Brilliance | 6. Special Blends |

PATTERSON PHOSPHORS are designed for maximum luminescence with minimum input energy. Quality phosphors for television, radar, oscilloscopes and other electronic instruments are available from Patterson Screen Division of E. I. du Pont de Nemours & Co. (Inc.), Towanda, Pa. Manufacturers, experimental laboratories and schools are invited to write us outlining their requirements.

PATTERSON
LUMINESCENT CHEMICALS

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY



STACKPOLE GA MIDGET CAPACITORS

goodbye to gimmicks!

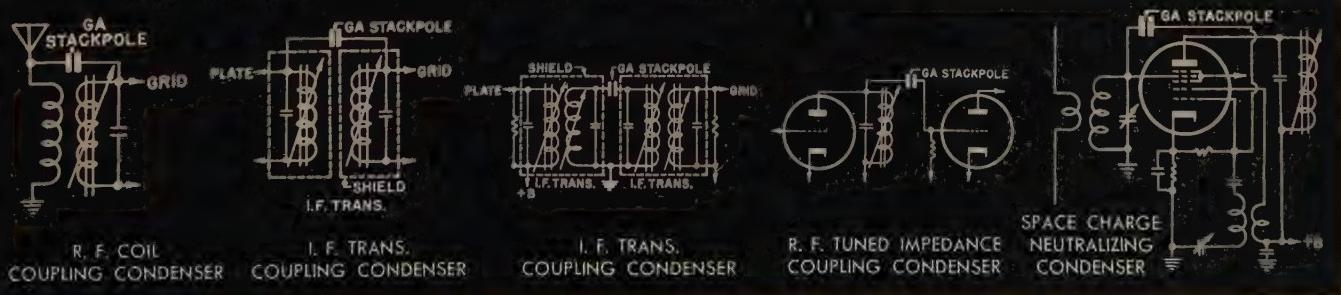
Still twisting insulated wires together to form inefficient, makeshift "gimmick" low value capacitors?

Stackpole GA Capacitors cost no more in the long run. Even more important, they bring you outstanding advantages in terms of greater stability, higher Q, better insulation resistance and higher breakdown voltage.

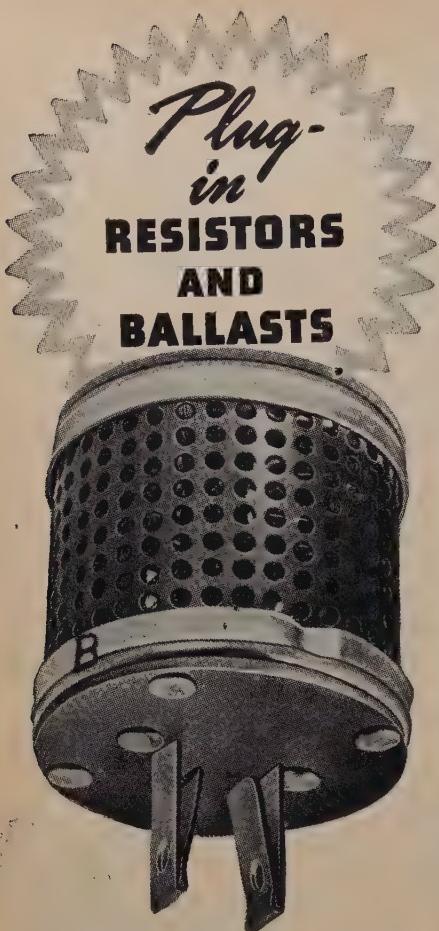
In addition, they are mechanically superior and eliminate the undesirable inductive characteristic common to twisted wires. Sturdily molded, with leads securely anchored and tinned, they are widely used in circuits similar to those illustrated. Standard capacitors include 0.68; 1.0; 1.5; 2.2; 3.3 and 4.7 mmfd. with tolerances of $\pm 20\%$.

Electronic Components Division

STACKPOLE CARBON COMPANY, St. Marys, Pa.



FIXED and VARIABLE RESISTORS • INEXPENSIVE SWITCHES
IRON CORES • COIL FORMS • POWER TUBE ANODES • BRUSHES AND CONTACTS • ALNICO II
RHEOSTAT PLATES and DISCS • ANODES and ELECTRODES, ETC.



★ Troubled by fluctuating line voltage? Just include a Clarostat Automatic Line Voltage Regulator in your assembly—or as an accessory plugged in between connecting cord and outlet. At 110 volts the resistance is low. Voltage drop is negligible. But as line voltage increases, the resistance builds up so as to maintain uniform and safe voltage to your assembly.

Clarostat also makes voltage-dropping resistors, such as for adapting 110-volt equipment to 220-volt power lines (particularly for export trade). Made either for built-in applications, or as convenient plug-in accessories.

★ Submit that problem . . .

If it has to do with resistors, controls or resistance devices, send it to us for engineering collaboration. Engineering catalog on request.



CLAROSTAT MFG. CO., Inc. • 285-7 N. 6th St., Brooklyn, N.Y.

News and New Products

(Continued from page 78)

giving materially better service in modern high speed, low amperage telegraph transmission operations than did other metals in the past.

Although relays with pure platinum and with the platinum-iridium alloy contacts worked effectively in the early days of telegraph transmission, the development of modern highly automatic telegraph transmission equipment created a critical problem in the matter of electrical contacts. The higher speeds at which the modern apparatus functions creates a tendency for the conventional metal contacts to fuse and oxidize.

It is stated that carbonyl contacts which have been attached by brazing to the marking and spacing contacts and the armature are self-cleaning. That is, material which becomes loosened through arcing, drops away from the carbide instead of fusing to the opposite contact as occurs on contacts made of conventional metals.



HIGH ACCURACY

In Measuring:

- * CAPACITANCE—RESISTANCE—INDUCTANCE
- * STORAGE FACTOR (Q) OF COILS
- * DISSIPATION FACTOR OF CONDENSERS
- MODEL 200-A IMPEDANCE BRIDGE is a portable, self contained instrument of highest quality used extensively by the Army, Navy, and many manufacturers.

The range of measurement for capacitance is 1 micro microfarad to 100 microfarads; for resistance, 1 milliohm to 1 megohm; for inductance, 1 microhenry to 100 henrys. The accuracy on the main decade is 1% for capacitance or resistance measurements and 2% for inductance tests.

Reading obtained from 6 inch direct reading dials. All controls and connections plainly marked and conveniently located on the panel. 35-page book gives methods for many types of measurements.

IMMEDIATE DELIVERIES

Our factory is in a position to make fast deliveries on Model 200-A and other products including precision mica condensers, binding posts, several types of AWS rheostat-potentiometers and decade and low capacity switches.

Brown Engineering Co.

4635 S. E. Hawthorne Blvd. Portland 15, Oregon

Meeting of Board of Directors of Radio Parts & Electronic Equipment Shows, Inc.

The Board is composed of the following men, reading left to right. Kenneth C. Prince, General Manager, Show Corporation; J. J. Kahn, Standard Transformer Corporation, Director; H. W. Clough, Belden Manufacturing Company, Presi-



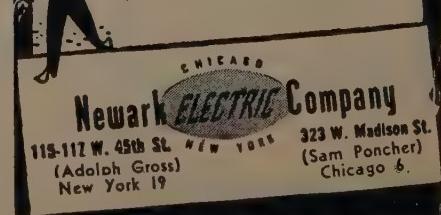
dent; John W. Van Allen, General Counsel, Radio Manufacturers Association; Bond Geddes, Executive Secretary, Radio Manufacturers Association; Leslie F. Muter, The Muter Company, Director; R. P. Almy, Sylvania Electronic Products, Director; Sam Poncher, Newark Electric Company, Director; J. A. Berman, Shure Brothers, Director; Charles Golenpaul, Aerovox Corporation, Director; W. O. Schoning, Lukko Sales Company, Director.

**FIRST
WITH THE
BEST**

When any leading manufacturer brings out a new product, you're sure to find it at Newark—as fast as the product is available. Standard items, too, are always part of the giant stocks of both Newark stores.

BIG NEW CATALOG!

Newark's new catalog will include everything for radio and electronics, and by writing for it now, you will also be placed on the list of those who receive Newark's famous bargain lists each month. Write today, addressing Dept. IR of nearest Newark branch.

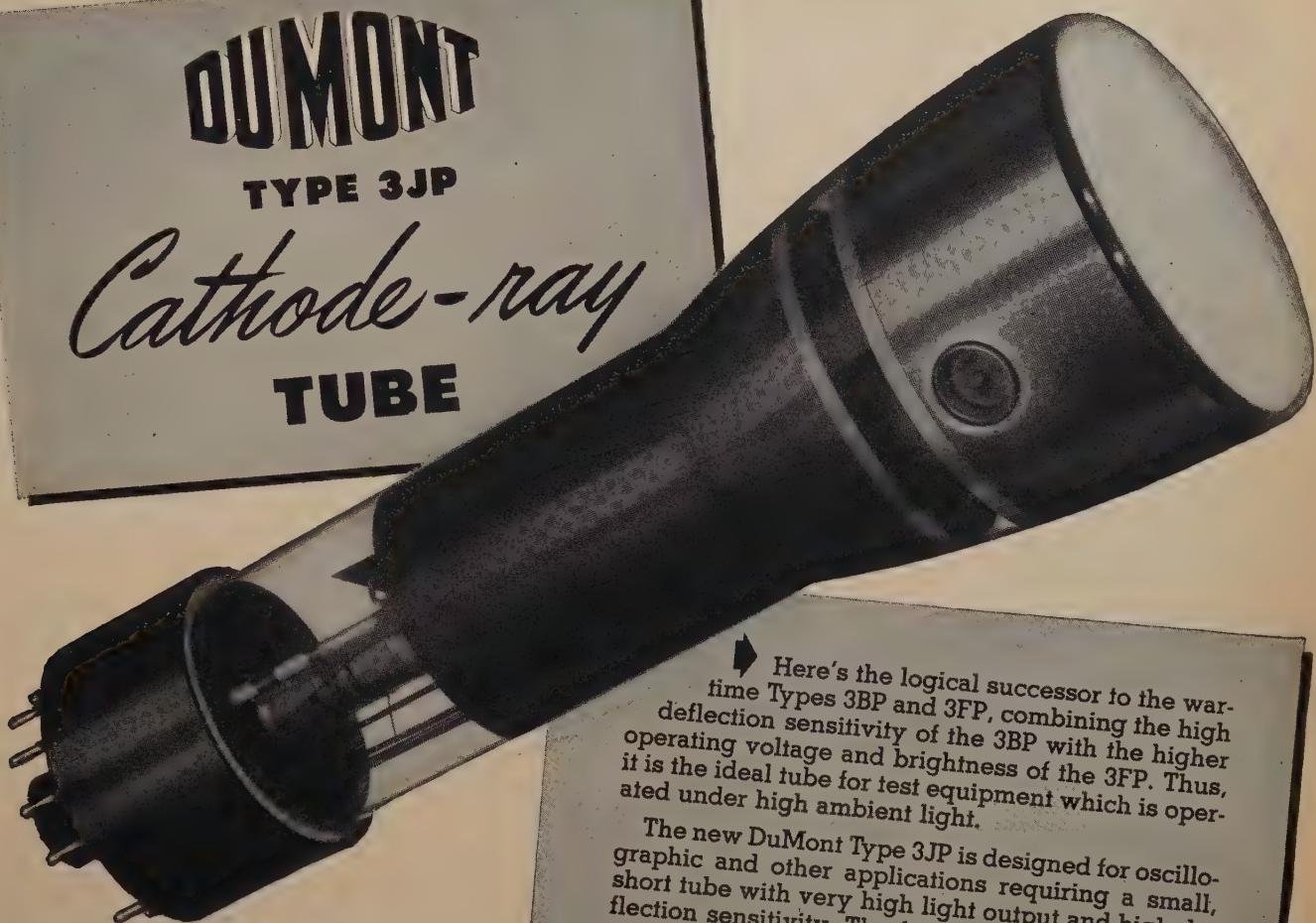


For greater brilliance and greater DEFLECTION SENSITIVITY—

DUMONT

TYPE 3JP

Cathode-ray
TUBE



CHARACTERISTICS . . .

Deflection and Focus Electrostatic
Screen: Choice of P1, P2, P4, P7
and P11 Screens

RATINGS:

Heater Voltage	6.3 a.c. or d.c.
Current	0.6 ampere
Anode #3 (Intensifier)	4400 volts max.
Anode #2 (Accelerating)	2200 volts max.
Anode #1 (Focusing)	1100 volts max.
Grid (Control Voltage)	Never Positive
Peak Voltage between Accelerating Electrode and Any Deflecting Electrode	550 volts max.
Grid Circuit Resistance	1.5 meg. max.
Impedance of Any Deflecting Electrode Circuit at Heater Supply Frequency	1.0 meg. max.
E _{b3} /E _{b2} Ratio	2.3 max.

MECHANICAL CHARACTERISTICS:

Overall Length	10"
Maximum Diameter	3"
Base	Med. 12-pin diheptal

Here's the logical successor to the wartime Types 3BP and 3FP, combining the high deflection sensitivity of the 3BP with the higher operating voltage and brightness of the 3FP. Thus, it is the ideal tube for test equipment which is operated under high ambient light.

The new DuMont Type 3JP is designed for oscillographic and other applications requiring a small, short tube with very high light output and high deflection sensitivity. The focusing electrode current under operating conditions is negligible, thereby simplifying bleeder design. The 2" dia. neck and diheptal base provide adequate insulation between electrode leads for high-altitude insulation.

For applications where deflecting voltages are under suitable control, the 3JP is directly interchangeable with the 3FP. Equipment using the 3BP may be readily adapted to use the 3JP by providing for connecting the intensifier electrode of the 3JP either to the second anode potential or to a higher potential than the second anode. Due to the higher deflection sensitivity, the 3JP can be utilized with intensifier potential equal to twice the second anode potential without reduction in sensitivity, as compared with the 3BP operating with the same second anode potential.

TECHNICAL DATA ON REQUEST.

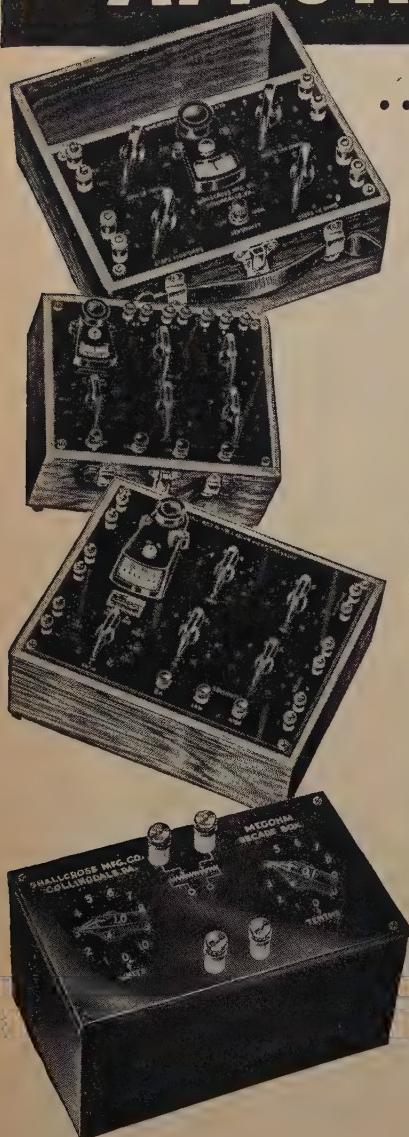
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DUMONT

Precision Electronics & Television

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.

INSTRUMENTS YOU CAN AFFORD TO USE



...on everyday jobs

INEXPENSIVE

ACCURATE

RUGGED

**EASILY REPAIRED
IN CASE OF MISUSE**

Hundreds of production line testing jobs and field investigations, in addition to laboratory tests require dependable instruments of a type that don't have to be kept under lock and key because of their extreme delicacy and high cost. Shallcross answers this need with many types of

**BRIDGES — DECADE BOXES
RESISTANCE STANDARDS
DECADE POTENTIOMETERS
HIGH-VOLTAGE TEST EQUIPMENT, etc.**

These instruments are accurate for every commercial and laboratory need up to the point of the most exacting research in pure physics. They are rugged, easy to operate and decidedly moderate in price. In case of misuse, they can quickly be repaired to full efficiency by any reasonably competent individual without the expense and delay of returning them to the factory.

WRITE FOR BULLETINS

Bulletin 810, Shallcross Resistance Standards

Bulletin 825, Resistance Decades

Bulletin D-1, Bridges

Bulletin LRT, Low Resistance Test Sets

Bulletin G, Electrical Measuring Apparatus for schools and colleges

SHALLCROSS MFG. CO., DEPT. IR-26 Collingdale, Pa.

SHALLCROSS

Electrical Measuring Apparatus • AKRA-OHM Resistors • Precision Switches • Electronic Engineering

BALTIMORE

"Generation and Transmission of Microwaves," by E. U. Condon, National Bureau of Standards; November 27, 1945.

"Technical Description and Discussion of AN/MPG-1," by A. E. Abel, M. Taylor, J. H. Taylor, and J. T. McNaney, Bendix Radio Division; December 18, 1945.

BOSTON

"The Future of Radar," by L. A. DuBridge, Massachusetts Institute of Technology; December 14, 1945.

CEDAR RAPIDS

"Practical Considerations in the Design of Very-High-Frequency Components," by W. W. Salisbury, Collins Radio Company; November 15, 1945.

CINCINNATI

"High-Frequency Measurements," by Arnold Peterson, General Radio Corporation; November 20, 1945.

CLEVELAND

"Romance of Clips," by Ralph Mueller, Mueller Electric Company; December 27, 1945.

Election of Officers; December 27, 1945

DALLAS-FT. WORTH

Cafeteria Supper and Inspection Tour of Telephone Building; November 27, 1945.

"Practical Problems of Frequency-Modulation Broadcasting," by M. W. Woodward, Commercial Radio Equipment Company, December 10, 1945.

DAYTON

"Atomic Energy," by M. L. Pool, Ohio State University; December 13, 1945.

DETROIT

"Squelch Circuits in Amplitude-Modulation and Frequency-Modulation Receivers," by F. M. Hartz, Detroit Edison Company; October 19, 1945.

"Improved Frequency-Modulation Circuits," by J. R. Boykin, Westinghouse Electric Corporation; November 16, 1945.

"The Sonic Bomb Scoring Recorder," by L. H. Larime, Technical Service, Inc.; December 21, 1945.

Election of Officers; December 21, 1945.

EMPIORIUM

"Review of War Electronics," by D. G. Fink, *Electronics*; December 13, 1945.

Election of Officers; December 13, 1945

LONDON

"Some Factors Involved in Sound Reproduction," by H. Goldin, Dominion Sound Equipments, Ltd.; December 14, 1945.

LOS ANGELES

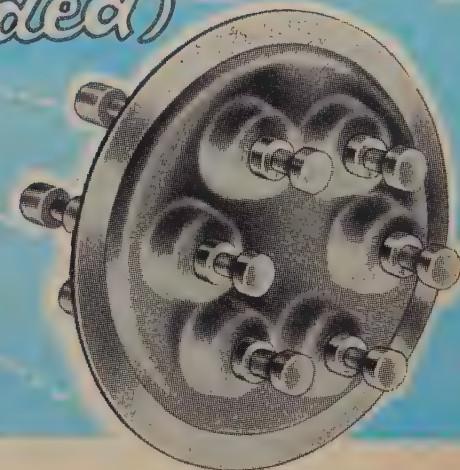
"New Analytical Viewpoints in Ultra-High-Frequency Engineering," by Simon

(Continued on page 40)



MYCALEX 410

(Molded)



UNITED TRANSFORMER CORPORATION
150 VARICK STREET



NEW YORK 13, N.Y.



Mycalex Corp. of America
30 Rockefeller Plaza
New York 20, N.Y.

Attention: Mr. Jerome Taishoff

Gentlemen:

We have conducted the following test on the two-six terminal
molded mycalex assemblies you submitted:

- 1 - Meg test - 500 megohms
- 2 - Place in oven at 40°C for 8 hours
- 3 - Place in hot sodium chloride at 65°C for 1 hour
- 4 - Place in cold sodium chloride at 0°C for 1 hour
- 5 - Leave overnight in salt water at room temperature 20°C
- 6 - Meg test - infinity test

This test was repeated three times. At the end of the test the unit was tested for leakage and showed a small amount. This amount was within the limitations imposed by the Army Signal Corps. After the assemblies had dried for about 15 minutes they indicated no leakage. We consider these terminals to be extremely satisfactory for hermetic sealing purposes.

We wonder what would happen if these same 6 terminals were compressed into a smaller diameter assembly? We would greatly appreciate receiving samples of your single terminal assemblies.

Yours very truly,
S. W. Levy
S. W. Levy
Chief Production
Engineer

MAKES "EXTREMELY
SATISFACTORY
HERMETIC SEAL"

REPORTS

United Transformer Corp.

Are you seeking a hermetic seal for transformer terminals? Do you want a low loss, high frequency insulating material that will bond to metal and give positive assurance against oil leakage and the damaging effects of moisture?

Then read the United Transformer Corporation report made after tests of MOLDED MYCALEX in conjunction with Monel Metal in this application. The results speak for themselves.

For 25 years MYCALEX has been known to engineers the world over as the "most nearly perfect high frequency low loss insulation." Now, in highly perfected form, MYCALEX offers new opportunities for product improvement.

Specify MYCALEX where low loss factor and high dielectric strength are required. Our engineers are at your service.



MYCALEX CORPORATION OF AMERICA

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Plant and General Offices, CLIFTON, N.J.

Executive Offices, 30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y.



*Stancor Delivers
Specified Performance*

**FEATURING PRECISION PRODUCTION
WITH TRUE ECONOMY...**

STANCOR is justly proud of its ability to meet all specialized transformer needs. At STANCOR, the combination of superior engineering skill and a long record of difficult and complex manufacturing problems successfully solved, unite to guarantee the production of transformers unexcelled in durability, service and economy.

Every individual specification that comes to STANCOR receives individualized attention and study . . . persistently and practically devoted to the ideal of "more performance per dollar."

Competent laboratory and sales engineering facilities are available NOW to meet your most exacting transformer specifications.



STANCOR
STANDARD TRANSFORMER CORPORATION
1500 NORTH HALSTED STREET CHICAGO 22, ILLINOIS



(Continued from page 38A)

Ramo, General Electric Company; November 27, 1945.

"The Engineer in Business for Himself," by Frank Pettit, Harvill Corporation, M. J. Brown, L. A. Chamber of Commerce; Douglas Sellers, Patent Attorney, H. J. Barnicoat, ERPI, M. Marquardt, World Broadcasting System; December 18, 1945.

Election of Officers; December 18, 1945.

OTTAWA

"Design Principles and History of Radar in Canada," by Fred Sanders, National Research Council; November 22, 1945.

Visit to the Montreal Road Laboratories of the National Research Council, and the Communications Building of the Royal Canadian Corps of Signals; December 13, 1945.

PHILADELPHIA

"Proximity Fuse for Gun-Fired Missiles," by R. H. Thayer; Johns Hopkins University; December 6, 1945.

"Proximity Fuze for Rockets, Bombs, and Mortars," by W. F. Hindman, National Bureau of Standards; December 6, 1945.

PITTSBURGH

"The History and Future of Radio Broadcasting," by L. W. Chubb, Westinghouse Research Laboratories; November 13, 1945.

"The Development of Atomic Energy," by J. R. Dunning, Columbia University; December 10, 1945.

PORTLAND

"Magnetic Sound Recording on Wire," by Henry Sturtevant, KALE; November 29, 1945.

ST. LOUIS

"Pulse Transmission and Pulse Modulation," by R. S. Glasgow, Washington University; December 20, 1945.

SAN DIEGO

"High-Fidelity Sound Reproduction," by W. G. Collins; Don Lee Broadcasting System; December 4, 1945.

SAN FRANCISCO

"Some Aspects of Intermediate-Frequency Amplifier Design," by Karl Spangenberg; Stanford University; December 19, 1945.

Election of Officers; December 19, 1945.

TORONTO

"High-Quality Sound Recording on Magnetic Wire," by L. C. Holmes, Stromberg Carlson Company; October 15, 1945.

Motion Picture: "A Record of Flight," October 15, 1945.

"Cathode-Ray Tubes for Television," by G. T. Waugh, General Electric Company; October 29, 1945.

(Continued on page 42A)

IT'S YOURS AGAIN . . . WITH NEW LAURELS!



**SIMPSON 260, HIGH SENSITIVITY SET TESTER FOR TELEVISION AND
RADIO SERVICING**

Ranges to 5000 Volts—Both A.C. and D.C.
20,000 Ohms per Volt D.C.—1000 Ohms per Volt A.C.

At 20,000 ohms per volt, this instrument is far more sensitive than any other instrument even approaching its price and quality. The practically negligible current consumption assures remarkably accurate full scale voltage readings. Current readings as low as 1 microampere and up to 500 milliamperes are available.

Resistance readings are equally dependable. Tests up to 10 megohms and as low as $\frac{1}{2}$ ohm can be made. With this super sensitive instrument you can measure automatic frequency control diode balancing circuits, grid currents of oscillator tubes and power tube, bias of power detectors, automatic volume control diode currents, rectified radio frequency current, high-mu triode plate voltage and a wide range of unusual conditions which cannot be checked by ordinary servicing instruments. Ranges of Model 260 are shown below.

Price, complete with test leads.....\$33.25
Carrying case4.75

Volts D.C. (At 20,000' ohms per volt)	Volts A.C. (At 1,000' ohms per volt)	Output
2.5	2.5	2.5 V.
10	10	10 V.
50	50	50 V.
250	250	250 V.
1000	1000	1000 V.
5000	5000	5000 V.

Milliamperes D.C.	Microamperes	Ohms
10	100	(12 ohms center)
100	0-1000	(1200 ohms center)
500	0-10 Megohms	(120,000 ohms center)

(5 Decibel ranges: -10 to +52 DB)

ASK YOUR JOBBER



• Originally designed as a radio service-man's test unit, the Simpson 260, because of its sensitivity and wide range was found adaptable during the war to general service duties in the entire electronics and electrical fields. It was given thousands of essential war jobs in the production and servicing of communications equipment.

Over 300 government agencies and university laboratories of the United States and Canada procured every one of these test instruments Simpson could deliver on an expanded war production schedule. They were turned out by the thousands. Every branch of the armed services — Army, Navy, Marines, Coast Guard — carried them to the far ends of the earth.

Chosen on its merits, the 260 became uniquely *the* test instrument of the war.

AVAILABLE NOW TO YOU

Now the Model 260, always the preferred instrument of radio servicemen, is available again to a widened field of peacetime services. We ask you to remember its record as an example of the quality and advanced engineering that goes into all Simpson instruments, as evidence that other new Simpson developments during 1946 are well worth waiting for. They are being released as soon as Simpson standards for their manufacture are satisfied. They will continue the leadership that has given Simpson a world-wide reputation for "instruments that stay accurate" with ideas that stay ahead.

SIMPSON ELECTRIC COMPANY
5200-5218 W. Kinzie St., Chicago 44, Ill.

Simpson
INSTRUMENTS THAT STAY ACCURATE

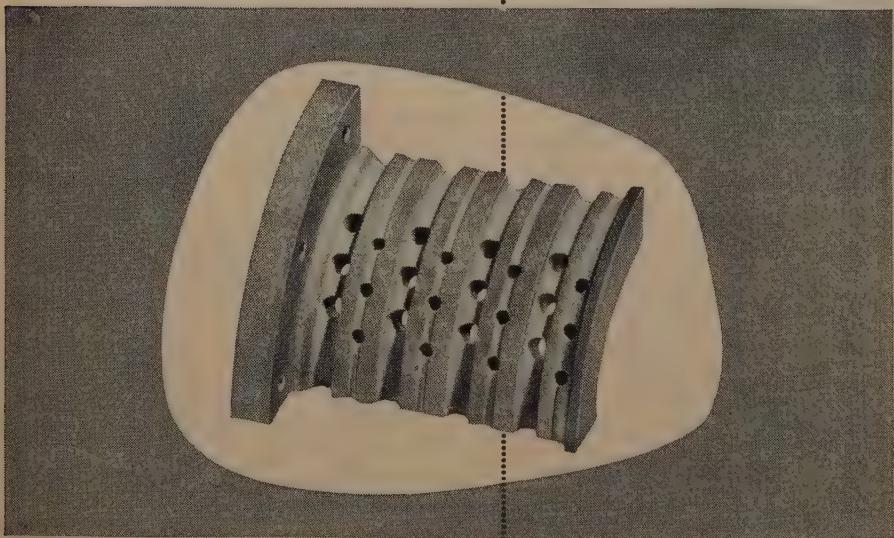
Case Histories from the RICHARDSON files

LAMINATED OR MOLDED PLASTICS

Problem: Produce quickly and economically an intricate yet sturdy control instrument part for use in aircraft.

Solution: To insure immediate delivery, Richardson fabricated this intricate part of Laminated INSUROK. At the same time, molds were being made. When these were finished, production of the part was shifted to Molded INSUROK. Thus, production continued without interruption, costly delays were avoided—another example of Richardson versatility!

The Richardson Company—to our knowledge—is the only plastics manufacturer fully equipped to do both laminating and molding of plastics . . . the molding of rubber and bituminous plastics . . . and the manufacturing of rubber-plastic combinations. These complete facilities enable us to meet your needs efficiently and economically! Find out how *Richardson Plasticicians* can help you improve both the appearance and performance of your products. Write today for information.



INSUROK Precision Plastics

The RICHARDSON COMPANY

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Sales Offices: NEW YORK 6 • CLEVELAND 15 • DETROIT 2
Factories: MELROSE PARK, ILL. NEW BRUNSWICK, N.J. INDIANAPOLIS, IND.



(Continued from page 40A)

Motion Picture: "R For Rubber,"; October 29, 1945.

"Frequency Modulation for Domestic Receivers," by R. A. Hackbusch, Stromberg Carlson Telephone Company; H. S. Dawson, Canadian Association of Broadcasters; and C. J. Irwin, Canadian General Electric Company; November 19, 1945.

TWIN CITIES

"Atomic Energy and the Engineer," by J. W. Buchta, University of Minnesota; December 5, 1945.



The following transfers and admissions were approved on January 9, 1946:

Transfer to Senior Member

Conte, T. M., 21 Forsyth St., Boston, Mass.

Craig, J. F., Hazeltine Electronics Corp., 58-25 Little Neck Pkwy., Little Neck, L. I., N. Y.

Cummings, K. M., United Air Lines, 5959 S. Cicero Ave., Chicago 38, Ill.

Hallmark, C. E., Farnsworth Television and Radio Corp., 3700 E. Pontiac, Fort Wayne, Ind.

Holloway, J., 150 Broadway, New York 7, N. Y.

Jorgensen, C. M., 1637 Balmoral Ave., Chicago 40, Ill.

Keto, J. E., Radar Laboratory, A.T.S.C., Wright Field, Dayton, Ohio

Metz, H. I., CAA Experimental Station, Indianapolis 44, Ind.

Moldawsky, B. W., 68-38 Yellowstone Blvd., Forest Hills, L. I., N. Y.

Okrent, J. J., 21 Barstow Rd., Great Neck, L. I., N. Y.

Salati, O. M., Hazeltine Electronics Corp., 58-25 Little Neck Pkwy., Little Neck, L. I., N. Y.

Seely, W. J., Duke University, Durham, N. C.

Tuttle, W. N., Lowell Rd., Concord, Mass. Walsh, A. A., 1403 Milford Terrace, West Englewood, N. J.

Admission to Senior Member

Austrian, R. B., RKO Television Corp., 1270-6 Ave., New York 20, N.Y.

Balasundaram, N., 29 Mahila College Rd., Lahore, India

Chase, C. T., 56 Carleton Rd., Belmont 78, Mass.

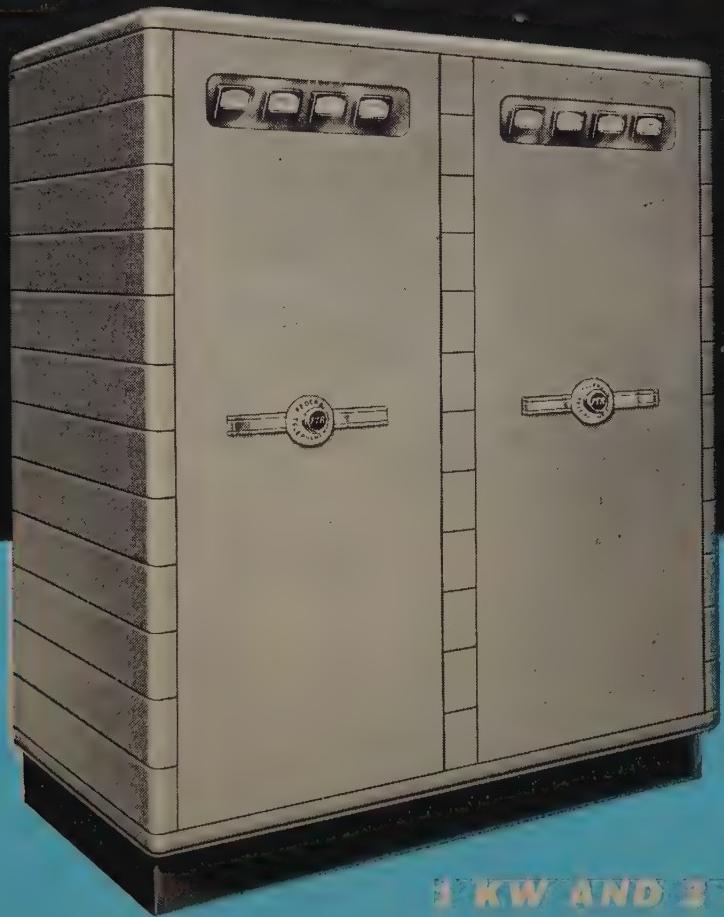
Crew, W. H., 11 Bolton Gardens, Bronxville 8, N. Y.

Duncan, R. C., Naval Ordnance Laboratory, Navy Yard, Washington, D. C.

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(Continued on page 44A)

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FEDERAL FM BROADCAST
TRANSMITTERS



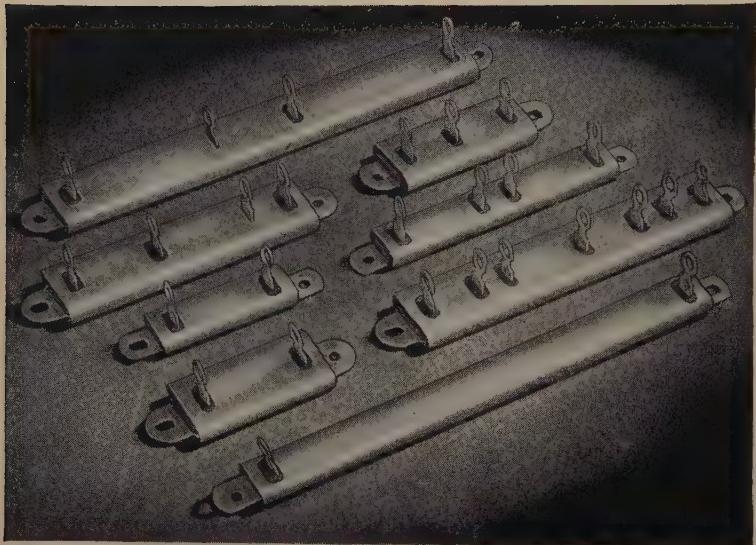
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(Continued on page 46A)

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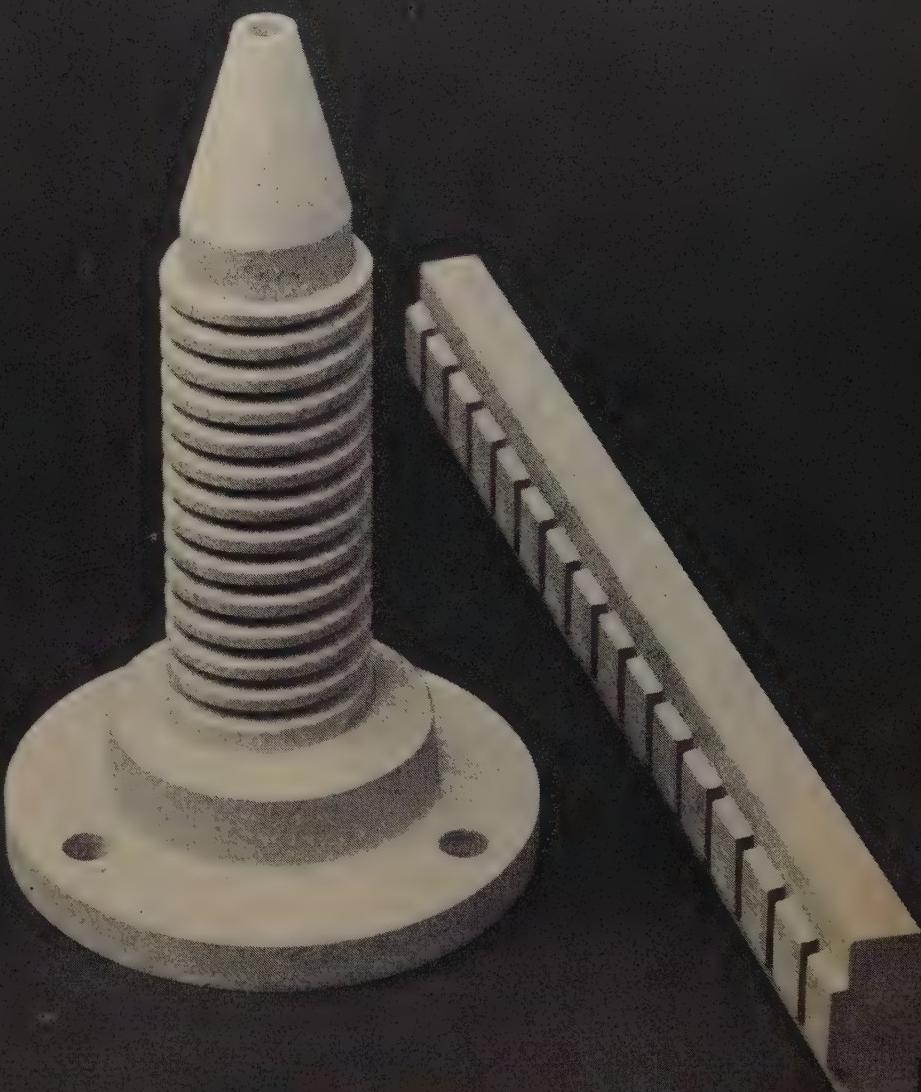
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(Continued on page 48A)

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(Continued on page 58A)

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(Continued on page 54A)

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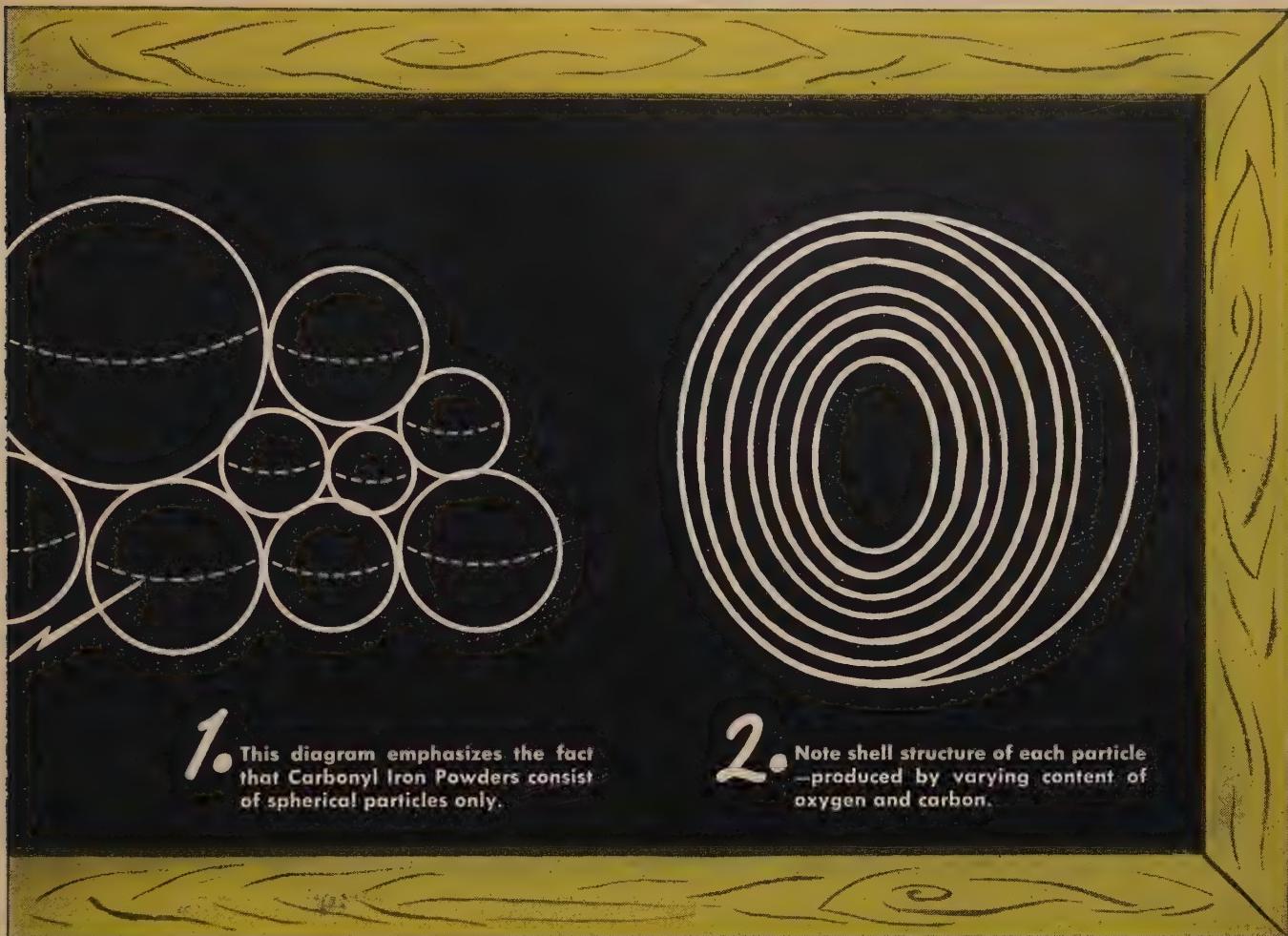
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1. This diagram emphasizes the fact that Carbonyl Iron Powders consist of spherical particles only.

2. Note shell structure of each particle produced by varying content of oxygen and carbon.

of carbonyl iron powder. The values given in the table are derived from measurements on straight cylindrical cores placed in simple solenoidal coils. Although the data were not obtained at optimum conditions, the Q

values as expressed in percentage of the best core give an indication of the useful frequency ranges for the different powder grades.

TABLE 2

Carbonyl Iron Grade	Effective Permeability at 1 kc	10 kc	150 kc	200 kc	1 Mc	100 Mc
L	4.16	100	96	90	43	1
C	3.65	94	100	98	72	3
E	3.09	81	94	100	97	30
TH	2.97	81	93	98	100	54
SF	2.17	62	71	78	84	100

(Note: The actually measured Q values can be obtained by multiplying the rows respectively with: 0.78, 1.09, 1.25, 2.63, and 1.62.)

"L" and "C" powders are also used as powder metallurgical material because of their low sintering temperatures, high tensile strengths, and other very desirable qualities. (Sintering begins below 500°C and tensile

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(Continued on page 60A)

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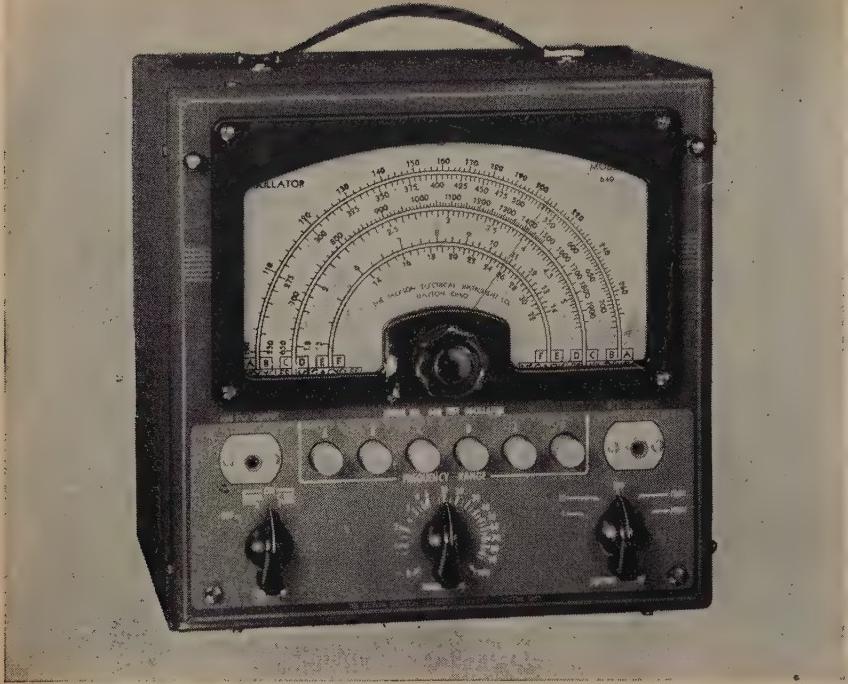


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(Continued on page 62A)

avoid damage from "in-the-package" moisture



SHIPPERS! Your product can be seriously damaged by rust, corrosion, or mildew . . . because of "in-the-package" moisture. Avoid such damage. Include Jay Cee Silica Gel, the ideal drying agent, in the packages with your product.

Your container may be sealed "tight as a drum" against outside moisture. Yet, the vapor within can cause untold harm. Particularly, a slight drop in temperature can release dangerous moisture.

Jay Cee Silica Gel keeps the air in the package dry . . . adsorbs the vapor . . . prevents moisture damage. Jay Cee Silica Gel is a crystalline substance resembling rock salt in general appearance . . . chemically inert. Has amazing power to take up moisture without its particles changing in size or shape. Packed in 1, 2, 4, 8 oz. and 1 and 5 lb. bags. Used widely with shipments of metal parts, precision instruments, electronic equipment, dehydrated foods, fabrics, and chemicals.

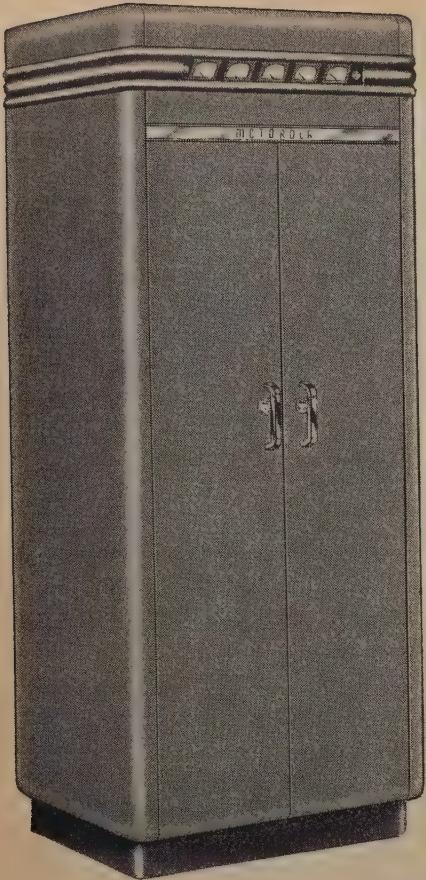


**no rust
no corrosion
in this container**

The illustration shows Mr. Otto Mueller, packaging foreman, inspecting one of his Ampro Sound-On-Film Projectors sealed tightly within a representative moisture vapor-proof barrier, ready to be placed in a shipping carton. Packed within the barrier, with the Projector, are three small bags of Jay Cee Silica Gel . . . which adsorb "in-the-package" moisture and prevent damage from rust or corrosion.

(Cellophane packaging was used in this illustration as a substitute for the actual wrapping).

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Coombs, G. F., 4635 Bermuda Ave., San Diego 7, Calif.
Cunningham, R. D., 329 S. Wilson St., Casper, Wyo.
Crompton, M. J., 25 Wickham Grove, Nth Essendon W. 5, Melbourne, Australia
Dexter, G. W., 2250 Carleton, Berkeley 4, Calif.
Dick, T. M., 38-25 Bell Blvd., Bayside, L. I., N. Y.
Dickon, A. J., 11 Squire St., Hartford, Conn.
Doronin, V. P., 1351 Park Rd., N.W., Washington 10, D. C.
Downs, E. E., 8 Rogers Ave., London, Ont., Canada
Dunlap, G. S., 2608 W. Haddon Ave., Chicago 22, Ill.
Dustman, H. C., 1431 S. 73 St., West Allis, Wisc.
Dyberg, T., Västergatan 33, Eslov, Sweden
Edmunds, J. J., Jr., RFD, Bridgewater, Me.
Fair, R. G., U. S. Coast Guard Air Station, San Diego 50, Calif.
Fallon, M. W., 117 Lake Ave., Newton Centre 59, Mass.
Fay, H. W., 450 N. Walnut St., East Orange 1, N. J.
Foschi, E. J., 322 Beach 74 St., Arverne, L. I., N. Y.
Friedrich, W. J., 515 (Rear) Lebanon Ave., Belleville, Ill.
Fukuda, F., 2920 Cass St., Detroit 1, Mich.
Gardner, D. R., 19308 Beacons Field, Detroit 24, Mich.
Geery, P. W., 2507 Shakespeare, Houston 5, Tex.
Gerber, I. B., 94 Portland St., Boston, Mass.
Gong, W. A., R.M.S. Staff, Treasure Island, San Francisco, Calif.
Grad, H., 743 Kelly St., New York 55, N. Y.
Greenwald, M. H., 5203 Arbor St., Philadelphia 20, Pa.
Gresslin, C. H., 1237 Hathaway, Lakewood 7, Ohio
Gulden, E. V., 14 W. Mayo Ave., Dayton 9, Ohio
Hance, L. V., RFD 1, Box 484, Michigan City, Ind.
Hannurker, L. G., c/o S.T.C. Mhow, Mhow, Central India
Harris, H. H., 514 Atlanta Ave., St. Louis 19, Mo.
Heaton, R. G., 8 Prescott St., Cambridge, Mass.
Henroteau, F. C., Farnsworth Television and Radio Corp., Fort Wayne 1, Ind.
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(Continued on page 64A)

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(Continued from page 62A)

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Jones, R., 35 Hiawatha Rd., Toronto, Ont., Canada

Judd, A. N., 52, Bushey Grove Rd., Watford, Herts., England

Kilby, P., Pattonville, Mo.

Klein, L. F., 1604 N. 60 St., Milwaukee 8, Wisc.

Koombes, I., 1442 Nelson St., Vancouver, B. C., Canada

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Krulikowski, S. J., Jr., Research Corp., c/o Dr. H. J. White, Bound Brook, N. J.

Lane, C. C., 39-34 Glenwood St., Little Neck, L. I., N. Y.

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Maxwell, R. S., 1312 E. Washington Blvd., Fort Wayne 4, Ind.

McKendry, J. K., 235 Payson Rd., Belmont 78, Mass.

McMenomey, J. M., 2061 S. Mountain Ave., Monrovia, Calif.

McMichael, J. T., 6624 W. Wells St., Milwaukee 13, Wisc.

Membery, A. H., 171 Earlsdale Ave., Toronto 10, Ont., Canada

Merrill, R. P., Clinton, Ont., Canada

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Miller, C. M., 954 Geary St., San Francisco 9, Calif.

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Nakagawa, S., Jr., 29 Macon St., Brooklyn 16, N. Y.

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(Continued on page 66A)

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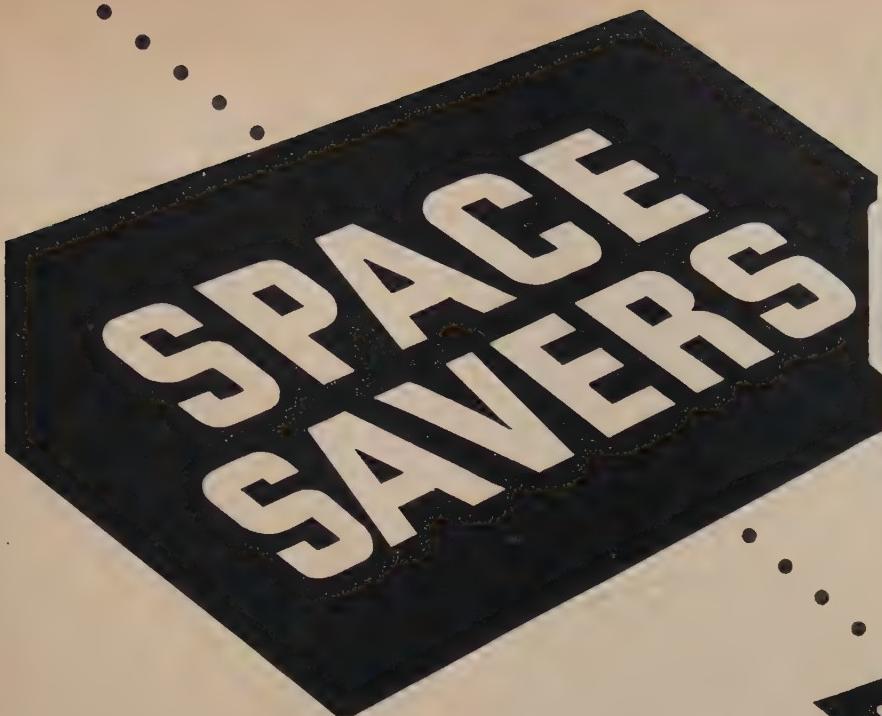
- Solid silver contacts and stainless silver alloy wiper arms.
- Rotor hub pinned to shaft prevents unauthorized tampering and keeps wiper arms in perfect adjustment.
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OY4G
ACTUAL SIZE



OY4
ACTUAL SIZE



RAYTHEON

IONICALLY HEATED LOW VOLTAGE GAS RECTIFIERS

A major deterrent to the further size reduction of radio receivers and other equipment designed for universal operation from a standard 117 volt AC or DC line or internal batteries, has been the size and power dissipation associated with the rectifier tube. The advantages of an ionically heated tube for low voltage applications were recognized early by the Raytheon engineers, who have long pioneered in the field of gas tube development. However, considerable research has produced the OY4 and OY4G which start cold from no more than 95 volts DC. High rectification efficiency is realized from the low internal drop and high peak current ratings. Physically these types have the same dimensions as the familiar OZ4G and OZ4.

Where size is an important factor, use of the OY4G in place of the 117Z6GT, as extensively employed in the three way receivers, will result in a substantial reduction of the space requirements.

OY4G AND OY4 RATINGS

Half Wave Rectifier—Condenser Input to Filter*

Maximum Inverse Peak Voltage	300 volts
Maximum Peak Current	500 ma
Maximum DC Output Current	75 ma
Minimum DC Output Current	40 ma
Minimum Series Anode Resistance (117V line operation) . . .	50 ohms
Approximate Tube Drop	12 volts
Maximum DC starting Voltage**.	95 volts

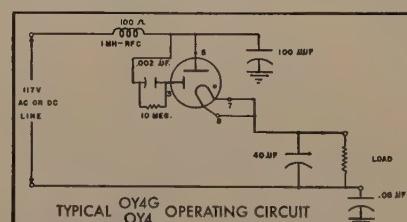
*Pins 7 and 8 must be connected together. Rapid intermittent operation is undesirable.

**With starter anode network as shown in circuit.

Even more important is the differential of approximately eight watts in favor of the OY4 and OY4G because of the ionic heating feature. This saving cuts the input power down by more than 50% for a normal receiver. Consequently, cabinet size can be decreased without danger of excessive heating. Furthermore, the time required for the set to become operative is the same whether on DC, AC or battery—that is, almost instantaneous.

These tubes have been engineered to produce a minimum of the radio frequency disturbances associated with a gaseous discharge. The simple filter circuit indicated below will generally reduce such interference to a negligible value.

If your product does not call for the ionically heated low voltage gas rectifier, there is a Raytheon type designed for your need. And all Raytheon tubes follow the same rigid pattern of advanced engineering with precision manufacture. To get continuing best results, specify Raytheon High-Fidelity Tubes.



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Smith, D. H., 33 Ferncliff Rd., Scarsdale, N. Y.
Soules, W. F., 1239 South Bend Ave., South Bend 24, Ind.
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Stouse, L. E., Jr., 1320 Octavia St., New Orleans 15, La.
Sullivan, A. D., 9385 Parkside, Brentwood 17, Mo.
Sulzer, P. G., RFD 112, Cheney, Pa.
Van Haaren, R. H. Ch., c/o Royal Dutch Airlines Curacao, Netherlands West Indies
Vermillion, R. K., 633½-2 St. N., St. Petersburg, Fla.
Walsh, L. R., Physics Dept., University of Illinois, Champaign, Ill.
Waterman, A. T., Jr., Box F, University Station, Austin, Tex.
Weill, A. E., 2440 N. Kedzie Blvd., Chicago 47, Ill.
Weirich, E. M., 5424 Byron St., Chicago 41, Ill.
Welch, R. C., Box 42, Tisdale, Saskatchewan, Canada
Welz, W. C., 2712 Leeland, Houston, Tex.
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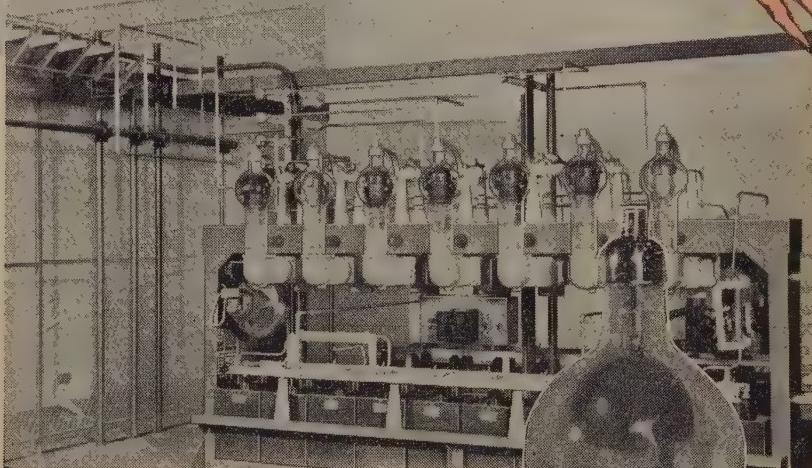


and the Japs yelled quits!

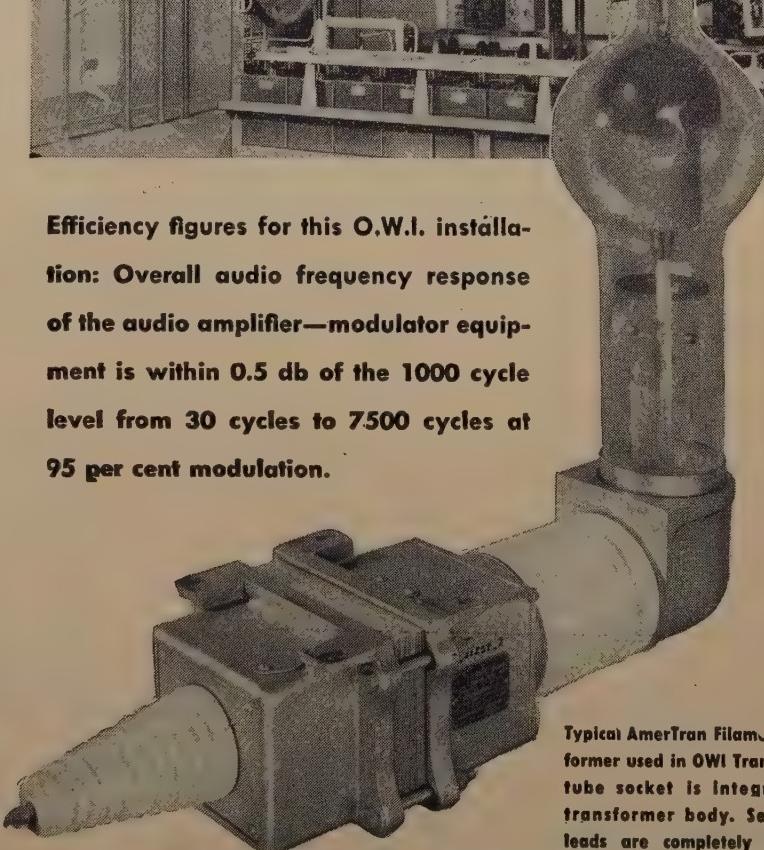


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Typical AmerTran Filament Transformer used in OWI Transmitters; tube socket is integral with transformer body. Secondary leads are completely enclosed.

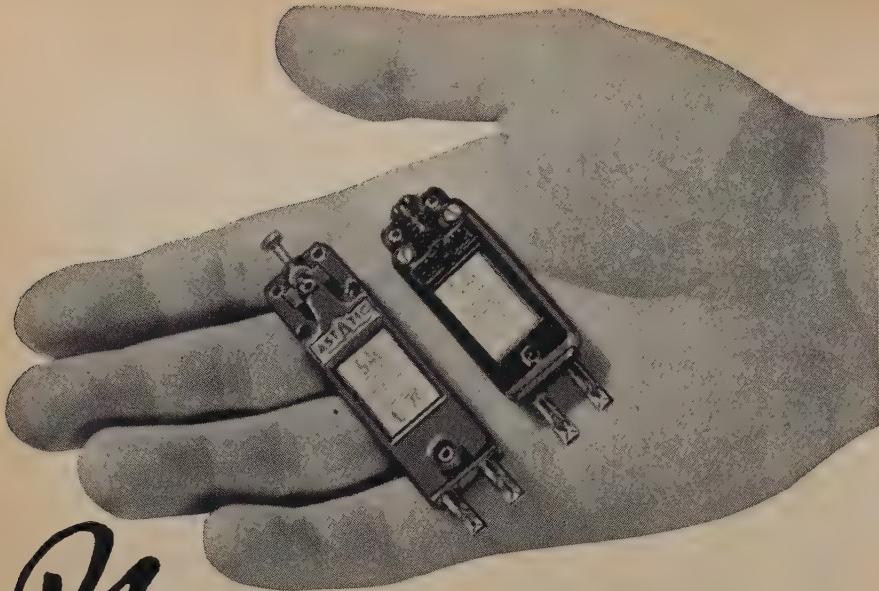
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ATLANTA

"The Multivibrator as a Signal Generator," by B. J. Dasher, Georgia School of Technology; May 25, 1945.

"Demonstration of New Methods of Program-Line Equalization," by Ben Akerman, WGST; June 22, 1945.

"A Description of the Developmental Frequency-Modulation Station at Tech, W4XAG," by M. A. Honnell, Georgia School of Technology; September 21, 1945.

BALTIMORE

"Significant Aspects of Magnetic Recording," by S. J. Begun, The Brush Development Company; October 23, 1945.

BOSTON

"Application of Circuit Theory to the Design of Servomechanisms," by A. C. Hall; Massachusetts Institute of Technology; November 16, 1945.

BUENOS AIRES

"Quartz Crystals and Their Applications—Second part: Various Cuttings—Piezoelectric Resonators—Basic Circuits," by Alejandro Rojo, Laboratory Transradio Internacional; September 21, 1945.

BUFFALO-NIAGARA

"Comparison of Frequency- and Amplitude-Modulated Signal Reception," by M. G. Nicholson, Colonial Radio Corporation; October 17, 1945.

"Tubes for the Proximity Fuze," by L. G. Hector, National Union Radio Company; November 21, 1945.

CEDAR RAPIDS

"Polyphase Broadcast Systems," by Paul Loyet, Radio Station WHO; October 18, 1945.

"Dehydration by Means of Radio Frequencies," by Mr. Himmel, President, Inter-Therm Company; October 18, 1945.

"Frequency-Modulation Falacies," by E. H. Armstrong, Columbia University; October 24, 1945.

CHICAGO

"Frequency Modulation," by E. H. Armstrong, Columbia University; October 29, 1945.

"The Atomic-Energy Project," by Malcolm Dole, Northwestern University; November 16, 1945.

"A Very-High-Frequency Omnidirectional Radio Range," by D. M. Stuart, Civil Aeronautics Authority; November 16, 1945.

CINCINNATI

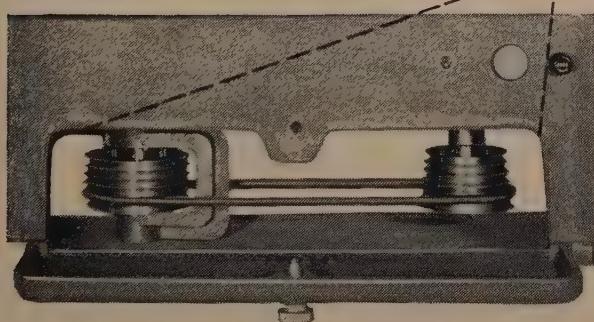
"Atomic Energy and Nuclear Physics," by I. A. Balinkin, University of Cincinnati; September 18, 1945.

"History of the Development of the Vacuum Tube," by I. E. Mouromtseff, Westinghouse Electric Company; October 16, 1945.

(Continued on page 38A)

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SECTION MEETINGS

(Continued from page 36A)

CLEVELAND

"Microwave Electronics," by E. U. Condon; Westinghouse Electric Company; September 29, 1945.

"Protection of Electronic Equipment and Mildewcides," by R. A. Shamel, Malinckrodt Chemical Works; October 25, 1945.

"Miscellaneous Gadgets," (in the Pacific Area), by R. A. Fox, WGAR; November 29, 1945.

CONNECTICUT VALLEY

↳ "Functional Use of Music," by Harold Burris-Meyer, Muzak Corporation; November 15, 1945.

DAYTON

"Air-Traffic Control," by G. A. Gilbert; Civil Aeronautics Authority; November 15, 1945.

INDIANAPOLIS

"Organizational Structure of Engineering Department," by M. C. Batsel; RCA Victor; September 28, 1945.

"Sound-Film Control Tracks and Dynamic Range," by E. W. Kellogg; RCA Victor, September 28, 1945.

"Automatic Positioner Mechanisms," by R. W. May, Collins Radio Company; October 26, 1945.

Election of Officers; October 26, 1945.

KANSAS CITY

"Some Recent Developments in Frequency-Modulation Transmission," by E. H. Armstrong, Columbia University; October 25, 1945.

"Very-High-Frequency Omnidirectional Radio Range," by S. R. Anderson, Civil Aeronautics Authority Experimental Station; November 27, 1945.

LONDON

"Fundamental Radar Circuit Design," by H. A. Ferris, National Research Council; October 26, 1945.

MONTREAL

"Fundamental Radar Circuit Design," by H. A. Ferris, National Research Council; October 31, 1945.

"Pulse Techniques," by R. W. Wilton Royal Canadian Air Force; November 15, 1945.

OTTAWA

"Application of High-Frequency Heating in Industry," by J. B. Knox, RCA Victor Company of Canada; October 11, 1945.

"Fundamental Radar-Circuit Design," by H. A. Ferris, National Research Council; November 1, 1945.

(Continued on page 42A)



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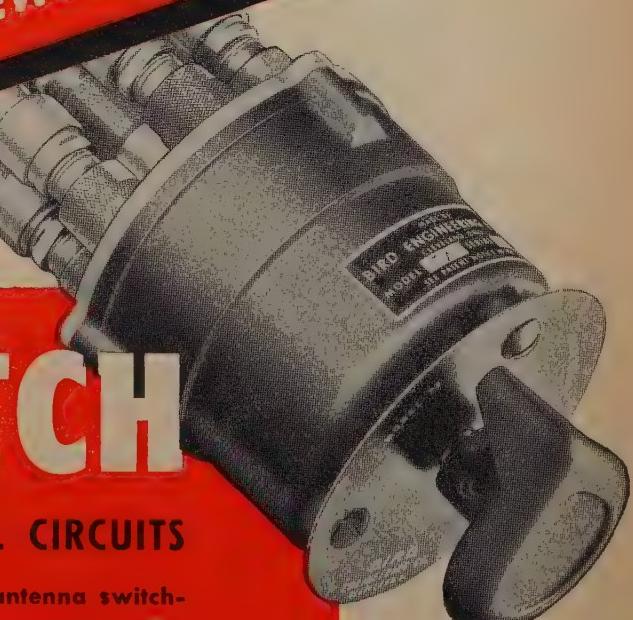
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This new switch was developed for airborne radar antenna switching. A 50-ohm device, it maintains a constant characteristic impedance. To retain LOW standing wave ratios and secure maximum transfer of r-f energy, specify "Coaxwitch". Available now, in two models; Model 74 for single coaxial circuits; Model 72-2 for handling two coaxial circuits simultaneously.

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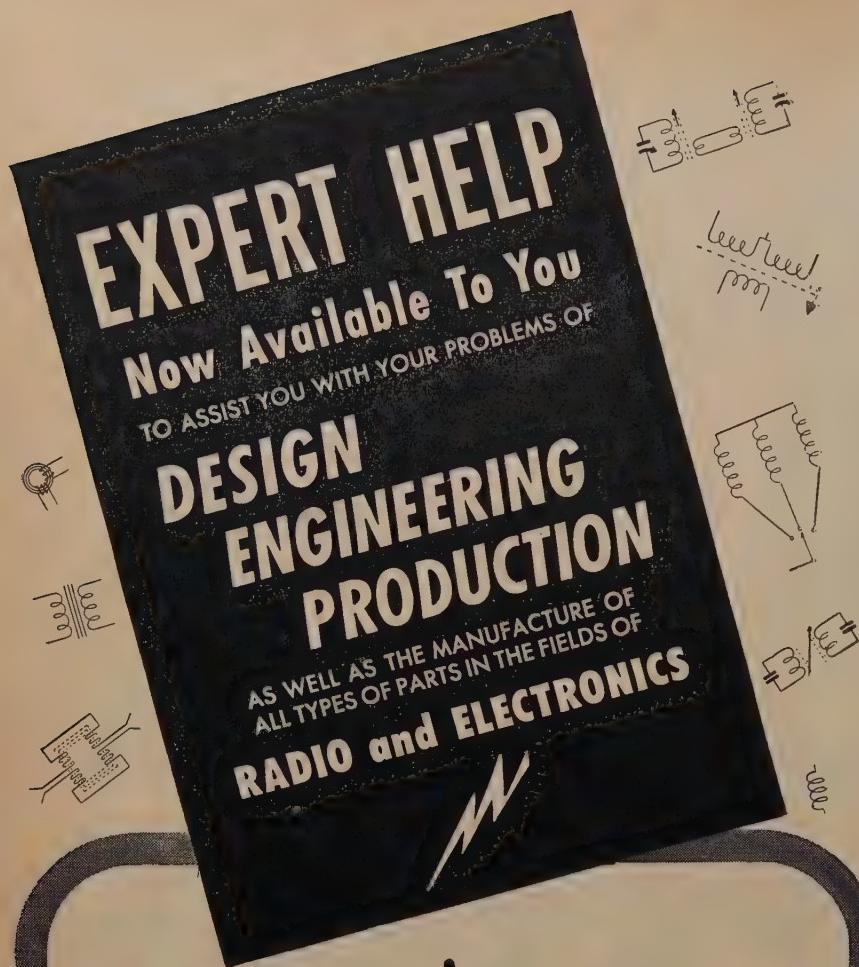


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(Continued from page 38A)

PHILADELPHIA

"Philco Philadelphia-to-Washington Television Relay Link," by F. J. Bingley, Philco Radio and Television Corporation; November 1, 1945.

ROCHESTER

"A Coaxial Modification of the Butterfly Circuit," by E. E. Gross, General Radio Company; November 12, 1945.

"The Radio Proximity Fuze," by H. Trotter, Jr., Eastman Kodak Company, November 12, 1945.

"Proximity-Fuze Tubes," by M. A. Acheson and H. K. Ishler, Sylvania Electric Products, Inc.; November 12, 1945.

"Microwave Radar," by D. G. Fink, McGraw-Hill Publishing Company; November 12, 1945.

"High-Quality Sound Recording on Magnetic Wire," by L. C. Holmes, Stromberg-Carlson Company; November 12, 1945.

"The Aurora and Geomagnetism," by C. W. Gartlein, Cornell University; November 12, 1945.

"Recent Developments in Converter Tubes," by W. A. Harris and R. F. Dunn, Radio Corporation of America; November 13, 1945.

"Industry Standardization Work in Television," by D. B. Smith, Philco Corporation; November 13, 1945.

"War Influence on Acoustic Trends," by H. S. Knowles, Jensen Radio Manufacturing Company; November 13, 1945.

"Germanium Crystals," by Edward Cornelius, Sylvania Electric Products, Inc.; November 13, 1945.

"Television—A Review of Technical Status," by E. W. Engstrom, Radio Corporation of America; November 13, 1945.

"Comments on Existing Television Systems From A Measurement Viewpoint," by Jerry Minter, Measurements Corporation; November 13, 1945.

"The Future of Radar," by L. A. DuBridge, Radiation Laboratory, November 13, 1945.

ST. LOUIS

"High-Frequency Antennas," by C. R. Cox, Andrew Company; November 29, 1945.

SAN DIEGO

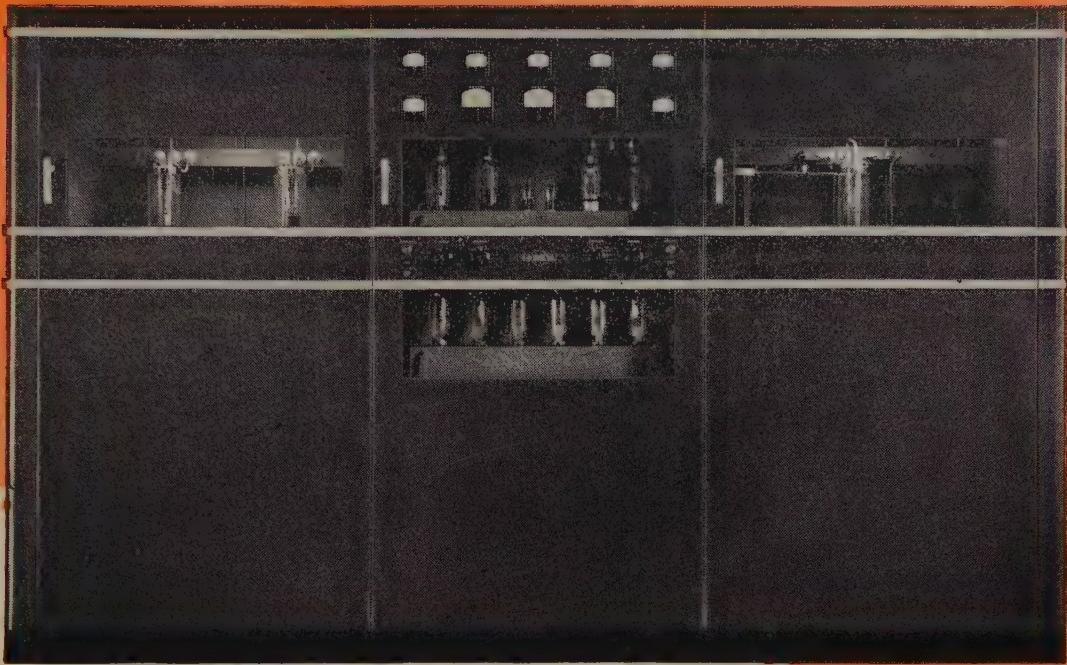
"Aircraft Radio-Compass Receivers," by K. E. Geren, University of California Division of War Research; November 6, 1945.

"General Aspects of Use of Aircraft Radio Compasses," by Tracy Barnes, Consolidated-Vultee Aircraft Corporation; November 6, 1945.

SAN FRANCISCO

"Present and Future Television," by Klaus Landsberg, Television Production, Inc.; April 9, 1945.

(Continued on page 44A)



Why WAAT bought its new 5 kw transmitter from Collins

The Bremer Broadcasting Corp., owners of WAAT, had had previous experience with Collins equipment. Mr. Frank V. Bremer, Technical Director, puts it this way:

"It is with interest and pride that I bring to your attention the performance of the Collins 20K one kilowatt AM transmitter installed at Kearny on April 14, 1941.

"This transmitter has been on the air a total of 39,000 hours, as of October 15, 1945, with a total elapsed lost time of only fifteen minutes.

"This makes a most remarkable record, since our station is on the air twenty-four hours per day, seven days per week, and it speaks well for your transmitter.

"According to the logs checked by Anthony Castellani, transmitter supervisor, the fifteen minutes total of lost air time was caused by defective bias tubes and a coupling

condenser in the audio circuit.

"At no time in the period of operation of the 20K have we had to make a refund or make up allowance to any sponsor due to lost air time.

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(Signed) Frank V. Bremer

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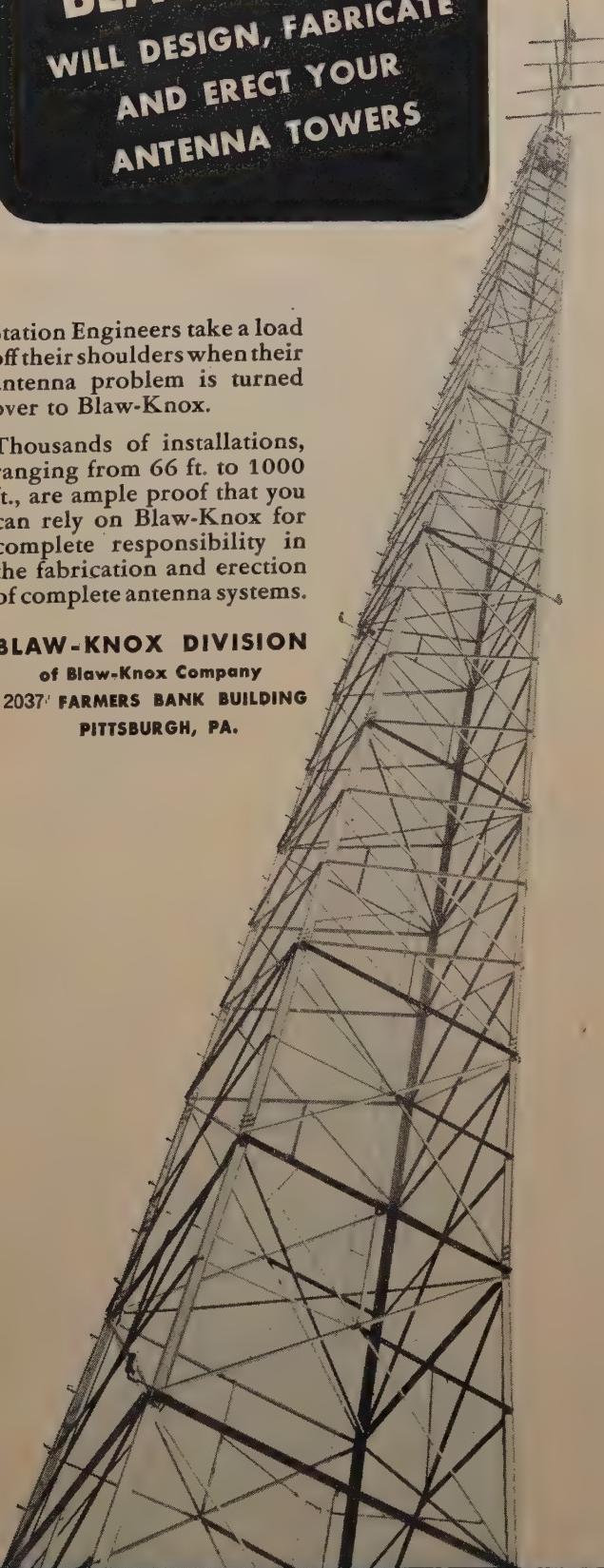


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BLAW-KNOX VERTICAL
RADIATORS

SECTION MEETINGS

(Continued from page 42A)

"Wartime Developments of Electronics," by W. L. Everitt, President, The Institute of Radio Engineers, Inc.; April 19, 1945.

Demonstrations of Microwave Characteristics by L. F. Black, University of California; May 23, 1945.

"An American Engineer in Europe," by R. V. Howard, Associated Broadcasters; July 18, 1945.

"Television-Studio Equipment," by Harry Lupke, Don Lee Television Station; September 19, 1945.

"Television-Studio Equipment," by L. E. Reukema, University of California; October 17, 1945.

"Predicted Television Coverage in the Bay Area," by Richard Brace, Associated Broadcasting Company; November 14, 1945.

SEATTLE

"Current-Stabilized-Supplies," by W. R. Hill, University of Washington; November 15, 1945.

TWIN CITIES

"Transformers and Filters," by W. E. Lehnert, Audio Development Company; November 6, 1945.

WILLIAMSPORT

"The Radio Proximity Fuze," by Herbert Trotter, Eastman Kodak Company; November 14, 1945.

SUBSECTIONS

COLUMBUS

"Lecture and Demonstration of U. S. Army Radio and Radar Equipment Used by Department of Electrical Engineering Research Department," by R. B. Jacques, Ohio State University; November 4, 1945.

PRINCETON

"The Development of the Proximity Fuze," by R. B. Roberts, Johns Hopkins University; December 4, 1945.

SOUTH BEND

"Application of Carrier Current and Space Radio To Electric Company," by G. G. Langdon, American Gas and Electric Service Corporation; October 23, 1945.

"The Atomic Bomb, Its Development and Use," by Bernard Waldman, University of Notre Dame; November 15, 1945.



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Clark, T. H., Federal Telecommunications Laboratories, 500 Washington Ave., Nutley, N. J.

Grosselfinger, W. H., Western Electric Co., 120 Broadway, New York, N. Y.

Hall, W. M., 1357 Massachusetts Ave., Lexington 73, Mass.

Isbister, E. J., 115 Lee Rd., Garden City, L. I., N. Y.

Jacobs, M., 171 E. Hillcrest Ave., Dayton 5, Ohio

Krakora, J. J., Jr., 1006 N. Leamington St., Chicago 51, Ill.

LaForge, L. H., Jr., 52 East Dr., Livingston, N. J.

Omer, C. L., 5904 Delmar, Mission, Kan.

Ports, D. C., 1226 Wisconsin Ave., N.W., Washington 7, D. C.

Robb, D. E., 264 Victor Ave., Dayton 6, Ohio

Woodward, M. W., 8238 Bellevue, Kansas City 5, Mo.

Striker, G. O., 3612 Franklin Blvd., Chicago 24, Ill.

Yolles, J., 257 E. Melford Ave., Dayton 5, Ohio

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Templin, E. W., 319 Lenox Ave., South Orange, N. J.

Truell, R., Department of Physics, Cornell University, Ithaca, N. Y.

Williams, H. P., 112, Pkwy., Welwyn Garden City, Herts., England

Transfer to Member

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Beier, M. G., 3930 Guilford Ave., Indianapolis 5, Ind.

Brantley, W. W., Maxwell Hotel, 20 and G Sts., N.W., Washington 6, D. C.

Bruene, W. B., 1239—1 Ave., S.E., Cedar Rapids, Iowa

Bulkley, A. W., 6907 Avondale Rd., Baltimore 12, Md.

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Castenholz, F. E., Police Department, Muskegon, Mich.

(Continued on page 48A)



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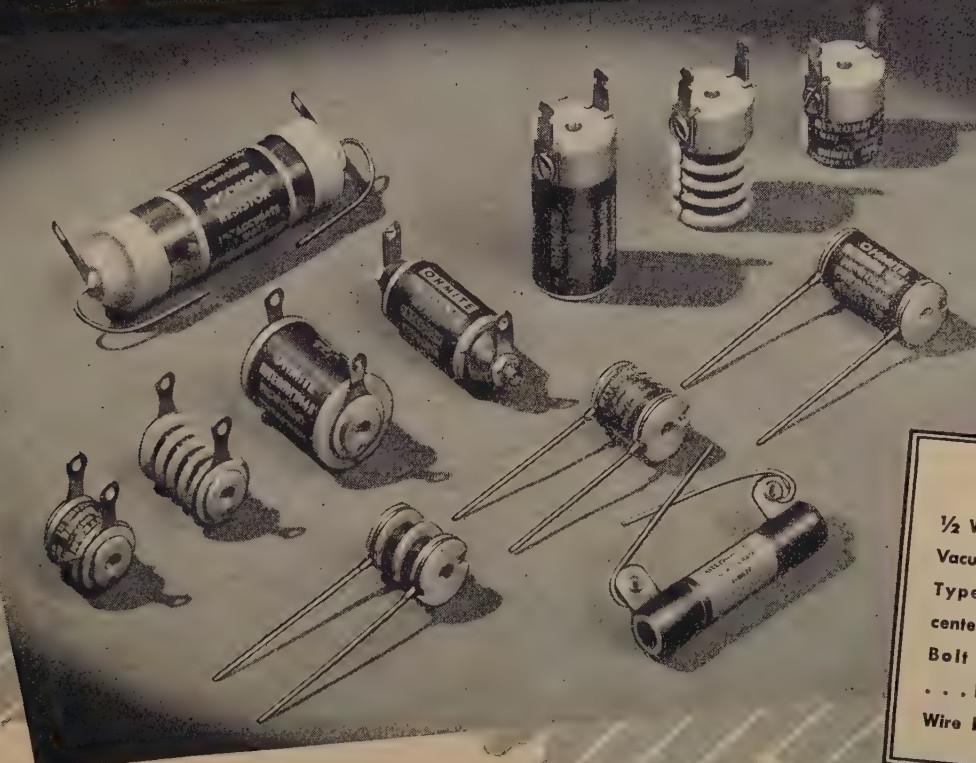
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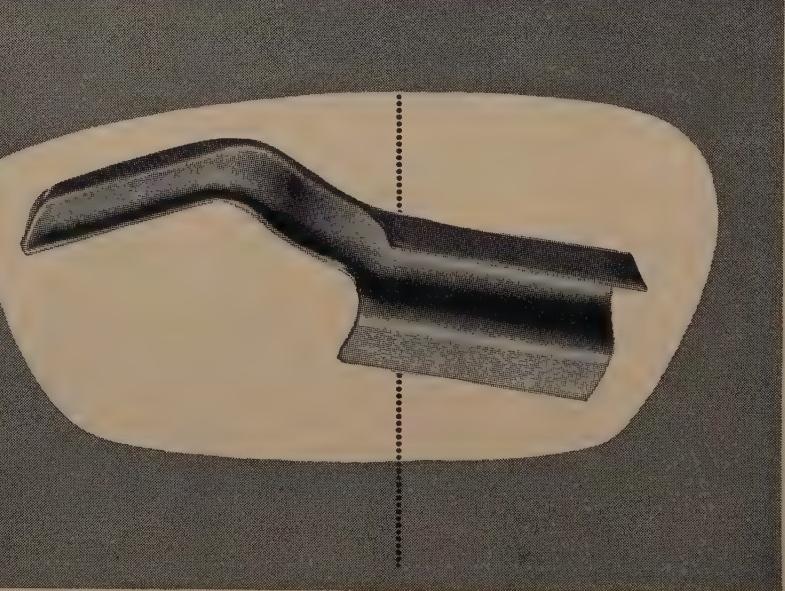
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Maki, G. J., Collins Radio Co., Cedar Rapids, Iowa
McKenna, W. E., 2993 Yorkway, Dundalk 22, Md.
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Palen, H. A., 122 E. Water St., Lock Haven, Pa.
Parchman, J. B., 18 Whitney Ave., Floral Park, L. I., N. Y.
Peake, H. J., 715 S. Washington St., Alexandria, Va.
Penners, B. A., 3678 Voltaire St., San Diego 6, Calif.
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Rinn, F. H., 24 S. High St., Lock Haven, Pa.
Schneider, A. E., 538 Rutherford Ave., Lyndhurst, N. J.
Shapiro, D. L., 118-53 Metropolitan Ave., Kew Gardens, L. I., N. Y.
Steidley, J. W., Code 911-G, Bureau of Ships, Navy Department, Washington 25, D. C.
Suski, H. M., Combined Research Group, Naval Research Laboratory, Anacostia Station, Washington 20, D. C.

(Continued on page 54A)



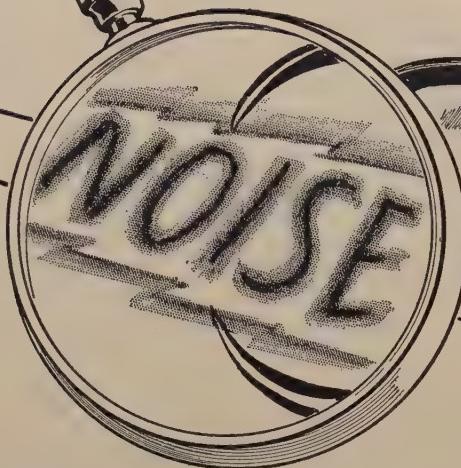
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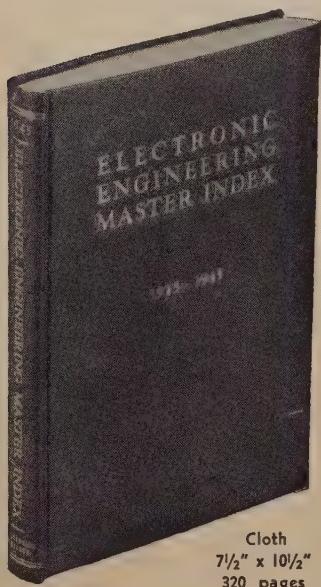
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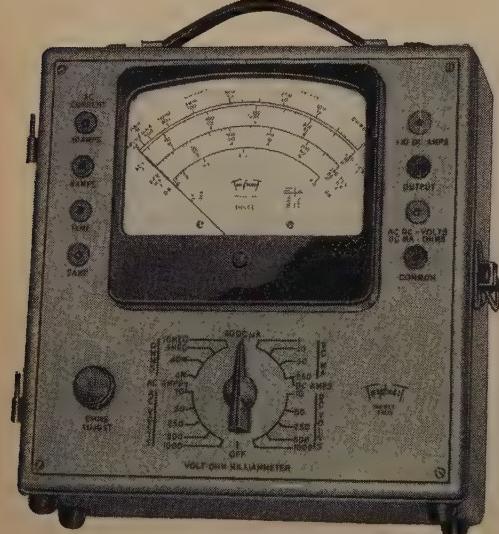
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Output Condenser in series with
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25,000 OHMS PER VOLT D.C.

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■ READABILITY—the most readable of all Volt-Ohm-Milliammeter scales—5.6 inches long at top arc.

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Ranges at 5000 ohms per volt.

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(Continued on page 56A)

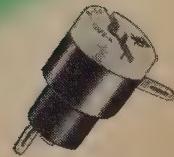


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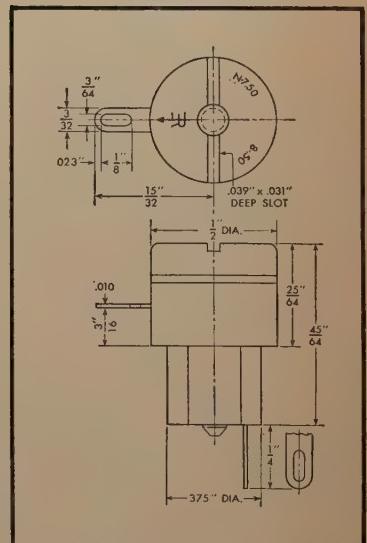
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Capacity change is essentially constant per degree of rotation, and full range is covered in 180° rotation. Type 554 Trimmers will be available shortly in production quantities in the following capacity ranges: in zero temperature coefficient, 3-12 MMF and 5-25 MMF; in -750 parts/million/°C, 5-30 MMF and 8-50 MMF. They will also be available in an intermediate temperature coefficient. Trimmers are held firmly in place in a D-hole in the chassis by means of a multiple-tooth spring clip, furnished with the trimmer.

Specifications and capacity ranges are given in the table at right. For complete information, contact our nearest representative or write us direct.



ACTUAL SIZE



Electronics Division

LONDON ENGLAND

TORONTO CANADA

EBIE 554 CEBAMICON TRIMMER

Voltage Rating: 350 volts D.C.
Flash Test: 700 volts D.C. for 15 seconds
Initial Q Factor at 1MC: 500 minimum
Initial Leakage Resistance: 10,000 meg. min.

New FOLDED UNIPOLE ANTENNA

Another Example of ANDREW
Ingenuity in Engineering

Concentrating on electrical performance, Andrew engineers have designed a unique Folded Unipole Antenna which—according to comparative tests—easily outperforms other antennas at several times the price.

Used for transmitting and receiving at frequencies from 30 to 40 MC and for powers up to 5,000 watts, this antenna has proved so successful that similar models for higher frequencies are now being designed.

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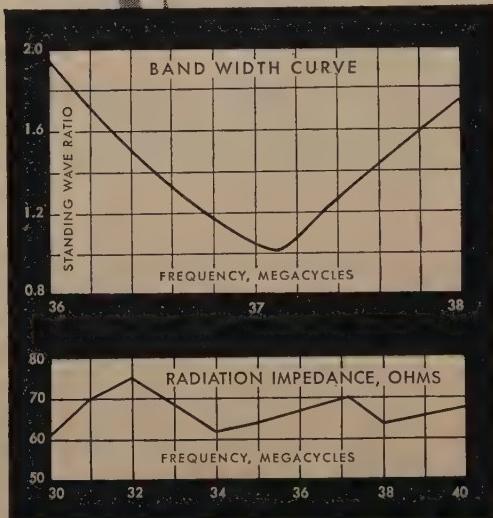
- Light weight — only 15 pounds — simplifies installation.
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Andrew Co. specializes in the solution of antenna problems. For designing, engineering and building of antenna equipment, consult Andrew Co.

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 Laban, J., 55 N. Menard St., Chicago 44, Ill.
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 Matthews, R. P., 2054 Claremont Ave., Montreal 6, P. Q., Canada
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 Mitchell, O. V., Radio Corporation of America, 30 Rockefeller Pl., New York 20, N. Y.
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On the crowded highways and skyways of the future, radio 'phone communication will keep traffic moving under quick, efficient control.

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The SHURE *Glider* Phonograph Pickup is equipped with the SHURE Lever-Type Cartridge

The "Glider" Pickup consists of the light-weight, low-mass Tone Arm and the Lever-Type Cartridge. The Arm is aluminum, uses no springs or counterweights and permits the needle-point to glide along the record smoothly and easily. This means longer needle and record life. The "Glider" is less susceptible to floor vibrations and improves the playing of warped records. The lightness of the Arm permits a needle force of only $1\frac{1}{8}$ oz. The "Glider" is especially suitable to the playing of the Vinylite records.

The Cartridge employs a radically different means of driving the Crystal Element. The Crystal is driven by a lever which considerably improves the transmission of needle chuck torque into the Crystal. Lower needle point impedance is obtained through this design, as well as greater immunity to shock. The lever arrangement absorbs the full impact of sudden jars to the Cartridge or needle, thus freeing the Crystal from strain or breakage. The output voltage is from 1.6 volts to over 3 volts. The new Cartridge is available in an aluminum case and weighs only .43 oz. (12 grams). The Cartridge is also furnished in steel, weighing .85 oz. (24 grams). The high needle-point compliance of this light-weight Cartridge affords "Faithful Tracking", which results in clearer, fuller tone qualities.

("Glider" Model Number is 93A)

Patented by Shure Brothers. Licensed under the Patents of the Brush Development Company.

SHURE BROTHERS

Designers and Manufacturers of Microphones and Acoustic Devices

225 West Huron Street, Chicago 10, Illinois
Cable Address: SHUREMICRO

SHURE



(Continued from page 56A)

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Court, G. W. G., T.R.E., Great Malvern, Worcs., England

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Crawford, B., Radio W9BDO, Seneca, Nebr.

Crise, G. M., Radio-Suisse S. A., Prangins, Switzerland

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(Continued on page 60A)

TELEVISION



Sherron Electronics

W2XDK

We Design - We Develop - We Manufacture

Television - FM - Transmitters and Studio Controls, Monitors and television test equipment.

Our demonstrated experience in designing, developing and fabricating equipment employing video amplifiers, cathode ray tubes, oscilloscope controls and allied circuits to television, establishes our skill and capacity to serve the Television Industry. Our Design section, Engineering department, Development section and Manufacturing department, staffed with expert and experienced personnel, enable us to offer to the television industry for their consideration:

Television Transmitters - Video and Aural
FM Transmitters
Studio Control Consoles
Master Control Boards
Transmitter Control Consoles
Audio Control Consoles
Television Test Equipment

Outstanding evidence of our service to the television industry is the establishment of our Experimental Station W2XDK. Over these facilities, transmitters, monitor controls - plus television test equipment - are subjected to operational inspection. This "proving-ground" assures the purchaser of Sherron Electronics Company Television equipment of tested and accredited broadcasting apparatus.

See our Television Exhibit
Booths 34 and 35
IRE Winter Technical Meeting
Hotel Astor
January 23, 24, 25, 26, 1946

SHERRON ELECTRONICS CO.

Division of Sherron Metallic Corp.

Brooklyn 6, N. Y. 1201 Flushing Avenue



STANDARD SIGNAL GENERATOR Model 80

SPECIFICATIONS:

CARRIER FREQUENCY RANGE: 2 to 400 megacycles.

OUTPUT: 0.1 to 100,000 microvolts. 50 ohms output impedance.

MODULATION: A M 0 to 30% at 400 or 1000 cycles internal. Jack for external audio modulation.

Video modulation jack for connection of external pulse generator.

POWER SUPPLY: 117 volts, 50-60 cycles.

DIMENSIONS: Width 19", Height 10 1/4", Depth 9 1/2".

WEIGHT: Approximately 35 lbs. **PRICE—\$465.00 f.o.b. Boonton.**

Suitable connection cables and matching pads can be supplied on order.

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY



METAL-TO-GLASS SEALS

Intricate glass work and tubes made to your specification

The Universal X-Ray plant specializes in the production of metal-to-glass seals. Intricate glass seals are made to customers' specifications for electronic tubes, transformers, resistors, capacitors, condensers, vibrators, switches, relays, instruments, gauges, meters, receivers, transmitters, and other scientific apparatus.

A strong metal-to-glass bond assures unfailing protection against rust, corrosion, and extreme climatic conditions in a vacuum-tight seal. Good deliveries can be made on volume orders. Submit your metal-to-glass seal problems to the Universal engineers for recommendations and estimates.

UNIVERSAL X-RAY PRODUCTS INC.

1800-K N, FRANCISCO AVENUE

CHICAGO 47, ILLINOIS



(Continued from page 58A)

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(Continued on page 62A)

Proceedings of the I.R.E. January, 1946

METAL ASSEMBLIES AND COMPONENTS FOR ELECTRONIC AND MECHANICAL DEVICES

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(Continued on page 64A)



New!

A SIMPLIFIED VERTICAL MOUNTING FOR SMALL TRANSFORMERS

Sizes fit Core Stacks with
 $\frac{1}{2}$ " to $\frac{3}{8}$ " center legs

To fully mount the smaller sizes of transformers, Chicago Transformer has developed a new, vertical, shield-type construction possessed of many outstanding characteristics.

- Readily adaptable to various chassis mounting requirements.
- Flexible in application to varying core thicknesses.
- Simple in design: two-unit construction makes for economy.
- Allows grounding of core by direct contact with mounting surface.
- Meets the requirements of the Underwriters' Laboratories.

CHICAGO TRANSFORMER

DIVISION OF ESSEX WIRE CORPORATION

3501 WEST ADDISON STREET

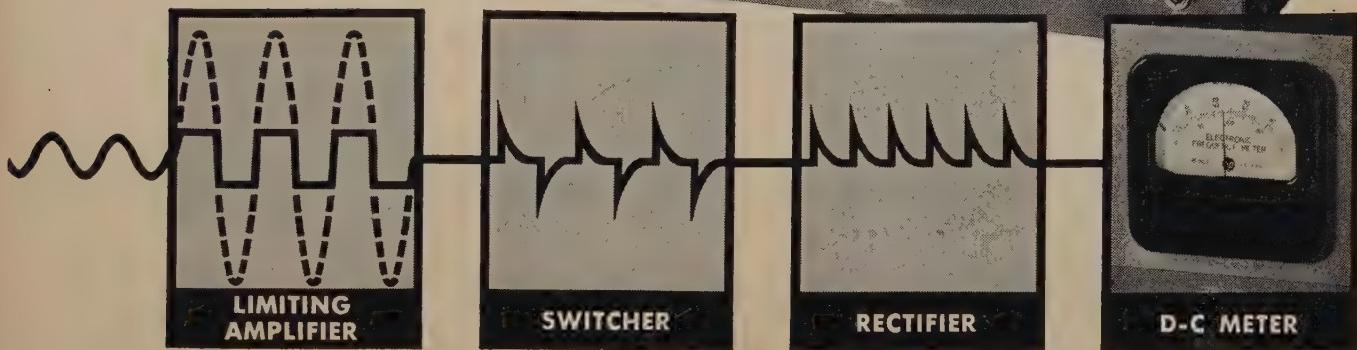
CHICAGO, 18





LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

What Happens Inside an -hp- Model 500A Frequency Meter



This Instrument Counts Cycles of an Unknown Frequency

The above diagram shows how the -hp- 500A analyzes an unknown frequency so that cycles per second will accurately register on the specially calibrated d-c meter.

The unknown frequency is introduced to a limiting amplifier which generates a square wave output. The square wave voltages are applied to two switching tubes which become alternately conducting on opposite half cycles. From a constant current supply, the two switching tubes deliver a current to load resistors. Each load resistor causes the charge on a pair of capacitors to vary in accordance with the switched current pulses. Thus a current flows from the combination to the rectifier. The rectified pulses are delivered to the d-c meter. Each pulse is of the same size and independent of other factors. The meter integrates these pulses and gives a deflection which is proportional to the number of

pulses per second. Thus the meter reading is directly related to the unknown frequency.

The instrument is easy to use and requires but a small amount of power. It has good sensitivity and a wide range of usable voltages. The input range is from 0.5 to 200 volts—input impedance is 50,000 ohms. A switch on the panel selects one of ten ranges which are read directly on the meter.

Accuracy of the instrument is $\pm 2\%$ —independent of line voltages, vacuum tube characteristics and magnitude and wave form of applied voltage—because the meter reading is dependent only upon the constant current supply and the RC combination.

The uses for this meter become readily apparent. Of special interest is its use as a high speed tachometer. (See column at right.) Write for more detailed information today. -hp- engineers are at your service.

HEWLETT-PACKARD COMPANY

BOX 1073D, STATION A, PALO ALTO, CALIF.

Audio Frequency Oscillators

Signal Generators

Vacuum Tube Voltmeters

Noise and Distortion Analyzers

Wave Analyzers

Frequency Meters

Square Wave Generators

Frequency Standards

Attenuators

Electronic Tachometers



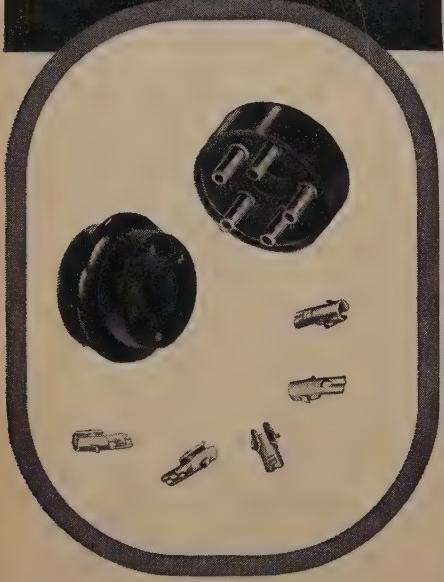
You can measure
3,000,000 r.p.m. with this
-hp- Electronic Tachometer

Using a photo electric cell pickup in conjunction with an -hp- Model 500A Frequency Meter provides an Electronic Tachometer capable of accurately measuring incredible speeds. This method places no load on the device being clocked.

Two special models of -hp- frequency meters, complete with light source and pickup, are available for this purpose. One model (505A) is calibrated in r.p.m. from 600 to 3,000,000 r.p.m.; the other model (505B) is calibrated in r.p.s. from 50 to 50,000 r.p.s. Speeds as slow as 600 r.p.m. (10 r.p.s.) are conveniently measured directly, while still slower speeds can be measured by a simple expedient.

Ask for special technical bulletin on -hp- Models 505A and 505B.

E BY # 60 S P E A K E R C O N N E C T O R S



SAVE APPROXIMATELY 25% IN ASSEMBLY TIME

Only 2 parts to Female Assembly:

1. The bakelite casting.
2. Eby patented snap-lock contacts.

Here's assembly speed! It's as simple as this:

Attach contact to wire and push into cavity.
Contact automatically locks in place.

(Casting and contacts supplied unassembled.)

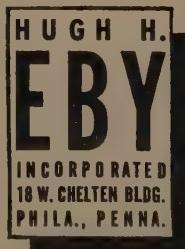
Male Assembly — nickel-plated brass prongs.

Bakelite casting — Standard arrangement for
3, 4, and 5 prongs. Other arrangements to
specifications.

Write today for samples and prices.

Eby #60 Male and Female Speaker Connectors
Are the Standard of the Industry

IF IT'S IN A CIRCUIT
... EBY COMPONENTS
AND SERVICES WILL
HELP YOU DO IT BETTER

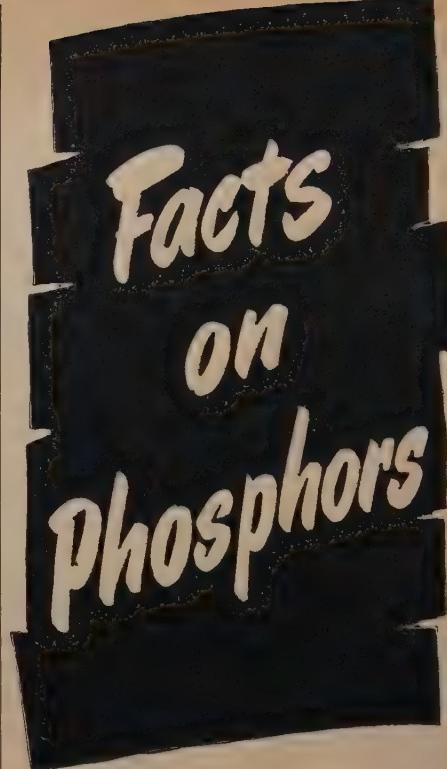


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(Continued from page 62A)

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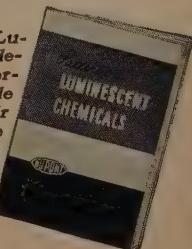
(Continued on page 78A)



HIGH GRADE Patterson phosphors, such as those required in the manufacture of cathode ray tubes and for scientific research, are now available in quantity.

For more than thirty years, the Patterson Screen Division of the Du Pont Company has produced luminescent chemicals for fabrication into x-ray screens. These screens have long been recognized throughout the world as the standard of screen quality. Patterson phosphors are known for their uniformity of emission, color and grain size. They meet exacting needs of a wide variety of specific requirements.

A BOOKLET—"Patterson Luminescent Chemicals" describes the general characteristics of various high grade phosphors and outlines their production. It will be mailed upon request. Patterson Screen Division of E. I. du Pont de Nemours & Co. (Inc.), Towanda, Pennsylvania.



Patterson
Luminescent
Chemicals



BETTER THINGS FOR BETTER LIVING
... THROUGH CHEMISTRY

*A Tube that Stands the GAFF
built by Federal*

Engineered

**Especially for HEAVY DUTY
Industrial Applications**

This high power industrial tube built by Federal is the result of the widening use of induction heating for heavy applications...especially designed for the purpose...built to meet the exacting demands of severe operating conditions.

Federal's 9C23 is a tube that can stand the gaff...with extra ruggedness for stamina...heavy duty filament for long life and high power output . . .

and with the inherent reliability and exceptional qualities that characterize every tube in the extensive Federal line.

Here is another instance where Federal's long experience and leadership in tube design and construction contribute to electronic progress. And it is a good reason to see Federal first for industrial power . . . rectifier . . . transmitting tubes.

Remember—"Federal Always Has Made Better Tubes."

Technical Data for Type 9C23

Maximum Ratings for Maximum Frequency of 20 Megacycles	
D C Plate Voltage	15,000 volts
D C Plate Current	4.0 amperes
Plate Dissipation	25 kilowatts
Filament Voltage	22 volts
Filament Current	82 amperes
Overall Length	19½ inches
Type of Cooling	water



Federal Telephone and Radio Corporation



Newark 1, N.J.

Permanent Magnets FOR LOUD SPEAKERS

From $\frac{1}{2}$ oz. to over 30 lbs. . . . and from start to finish . . . Arnold manufactures better Alnico permanent magnets for loud speakers. They are now available for all civilian applications, and include the proposed Radio Manufacturers Association standard speaker magnets in Alnico V.



The speaker magnets illustrated above are representative, yet are just one type of permanent magnets described in the new 24-page Arnold bulletin, "Permanent Magnets for Industry."

WRITE TODAY on your company letterhead
FOR THIS NEW BULLETIN



THE ARNOLD ENGINEERING COMPANY

147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

Specialists in the manufacture of
ALNICO PERMANENT MAGNETS

Peacetime Development of New Weapons

No sooner had news of the complete victory in Japan reached this country than the War Department of the United States of America began placing into effect a plan which should bring comfort and confidence to all but future potential enemies.



HARRY DIAMOND

Remembering the days of Pearl Harbor, days that caught the Nation unprepared, an unpreparedness that can be measured only in the countless numbers of lives sacrificed in the effort to stem the surge of the aggressor nations; remembering these things, there has been awakened the realization that even the powerful nations might never survive if caught in the storm of another war in the same state of preparedness as the United States faced on December 7, 1941.

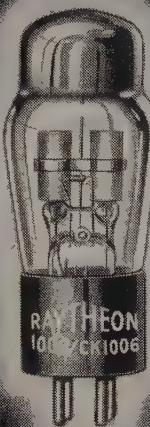
Silently but swiftly on V-J Day, machinery was placed in operation under a plan which had been set up as far back as October, 1944, and held in readiness for the war's end, the plan to provide the United States with the best weapons and counterweapons ever conceived, weapons which would exceed the best any potential enemy could devise, weapons such that no other nation would venture to entertain the idea of an attack.



ROBERT O. HUNTOON

Evidence of this plan was revealed in an announcement by the Secretary of War on October 24, 1945, of Army Ordnance plans

(Continued on page 68A)



1/2 ACTUAL SIZE

RAYTHEON TYPE 1006/CK1006 A HEAVY DUTY FULL-WAVE GAS RECTIFIER

TYPE 1006/CK1006 RATINGS FULL-WAVE RECTIFIER SERVICE

	Ionomically Heated	Heated	Directly
Filament Voltage	0	1.75	volts
Filament Current	0	2.00	amps
Maximum Peak Anode Voltage (per anode) no load	800	800	volts
Maximum Peak Inverse Voltage	1500	1600	volts
Average D.C. Voltage Drop	30	25	volts
Maximum D.C. Output Current	200	200	ma.
Minimum D.C. Output Current	70	0	ma.
Minimum Starting Peak Voltage (half wave or dc)	650	450	volts
Minimum Starting Peak Voltage (full wave)	550	420	volts
Maximum Steady State Peak Anode Current per anode	600	600	ma.

RAYTHEON
MANUFACTURING COMPANY

Excellence in Electronics

RADIO RECEIVING TUBE DIVISION

NEWTON, MASSACHUSETTS NEW YORK CHICAGO

To supply the requirements of small transmitters or other equipment where rectification efficiency must be maintained at a high level, Raytheon engineers developed type 1006/CK1006.

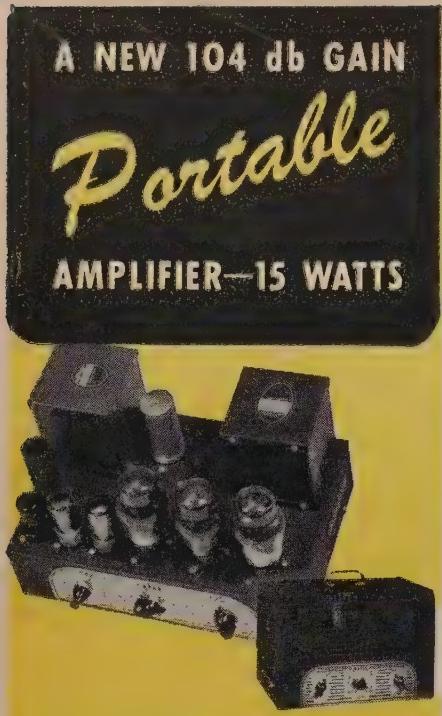
Utilization of an inert gas enables this tube to perform its functions through a wide range of ambient temperatures. The cathode may be directly heated as shown in the ratings—or where greater efficiency is desired, ionic heating is possible provided the specified minimum load is maintained without rapid intermittent operation. The internal drop is low even during the time rated peak current is flowing.

A very important feature of the 1006/CK1006 is the fact that *no cathode preheating time is required*. Full load can be handled immediately and starting is practically instantaneous.

Obviously, the foregoing electrical characteristics are applicable to many types of mobile equipment. Structurally, too, the 1006/CK1006 fits well into such service because rugged design allows it to withstand considerable shock without change in characteristics.

Many thousands of Raytheon 1006/CK1006 tubes have individually given hundreds of hours of reliable service in equipment subjected to adverse conditions of temperature and vibration. Another convincing "exhibit" of evidence that Raytheon builds fine tubes . . . tubes well worth considering for your postwar products!

BUY
VICTORY
BONDS



The new Altec Lansing A-323 portable amplifier is specifically engineered to operate adequately from low level phonograph pick-ups, microphones or radio tuners. Up to its rated power, it reproduces high quality sound over the full frequency range without overload or distortion. It is a small, compact, 6-tube portable amplifier especially designed and manufactured to efficiently operate with the Duplex Speaker, public address systems, home radio receiving sets and other applications where high quality, low cost amplification is desired.

\$118⁰⁰

WITH INPUT TRANSFORMER
\$158⁰⁰

AT ALL LEADING DEALERS
OR SEND YOUR ORDER TO

ALTEC

LANSING CORPORATION

1210 TAFT BLDG., HOLLYWOOD 28, CALIF.
250 WEST 57 STREET, NEW YORK 19, N. Y.
IN CANADA: NORTHERN ELECTRIC CO.

Peacetime Development of New Weapons

(Continued from page 66A)

for pressing vigorously new research on the radio proximity fuze, one of the top secret weapons of the war. On October 31, 1944,



CLEO BRUNETTI

General L. H. Campbell, Chief of Army Ordnance, asked the National Bureau of Standards to set up a postwar establishment for carrying on development work on electronic ordnance under Army sponsorship. In a memorandum to Dr. Lyman J. Briggs, director of the National Bureau of Standards, General Campbell requested the Bureau to undertake a program of development of new and better radio fuzes and other electronic weapons. What these other weapons are is not known, but it suffices that these practical scientists who proved their worth in the radio-fuze development can be depended on to do a job worthy of confidence.

Selection of the National Bureau of Standards as the center of this important work was based on its extensive experience for the past four years, in which the Bureau pioneered in the development of the radio fuze and other devices, the latter in the category of secret weapons as yet unrevealed



C. H. PAGE

to the public. Together with the Johns Hopkins Applied Physics Laboratories, the Bureau served as the focal point for all radio-fuze development in this country and

(Continued on page 70A)

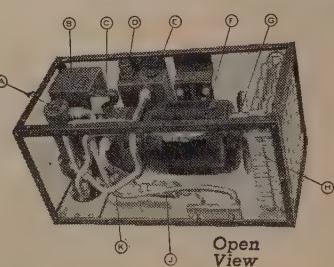
EASTERN HEAT DISSIPATING UNIT

The Eastern Heat Dissipating Unit is used in connection with television, radar, short wave radio communications, high pressure mercury lamps, X-Ray tubes, induction heating units, and many other applications. It was developed for military requirements in conjunction with radar and electronic tube cooling problems. Units were designed in various sizes and capacities, some with the close heat control range of 2 degrees C. Used successfully for ground, water and airborne service, they combine rugged construction, compactness and light weight.

The model illustrated will dissipate up to 1200 watts with a constant controlled temperature, irrespective of surrounding temperatures, within 2 degrees C. It is complete with Thermostat control, Thermostatic valves and flow switch. Eastern has built airborne units of much smaller sizes and industrial units of much larger sizes and capacities. The specifications for the unit shown are: SIZE: 16" x 7 1/2" x 7 1/2"; METALS: Steel, Bronze, or Aluminum. Other models can be designed to dissipate up to 5000 watts.



Closed View



Open View

- | | |
|--------------------------|-------------|
| A. Thermo flow-regulator | F. Motor |
| B. Reservoir | G. Fan |
| C. Flow Switch | H. Radiator |
| D. Thermostat | I. Filter |
| E. Auxiliary Heater | K. Pump |

Eastern's experience in solving heat control problems, especially where compactness and light weight are necessary, makes them the logical people with whom to discuss heat control applications. If you are designing or planning to build equipment that calls for heat dissipation or the close control of operating temperatures, Eastern will design and build the entire unit for you to meet your specific requirements.

An inquiry about your heat dissipating needs will not obligate you in the slightest.

A large part of Eastern's business is the designing and building of special pumps, in quantities ranging from 25 to several thousand for the aviation, electronic, chemical, machine and other special fields. Eastern builds over 600 models, both centrifugal and positive pressure, ranging in size from 1/100 H.P. to 3/4 H.P. as standard units.

Eastern Engineering Co.

86 FOX STREET, NEW HAVEN 6, CONN.



CLAIM STAKING

Hallicrafters and Very High Frequency

Based on the facts in the case, Hallicrafters can stake out a very strong claim to leadership in the very high frequency field. The facts include such things as the Model S-37, FM-AM receiver for very high frequency work. The Model S-37 operates from 130 to 210 Mc.—the highest frequency range of any general coverage commercial type receiver.

Hallicrafters further supports its claim to domination in the high frequency field with the Model S-36A, FM-A M-CW receiver. The 36A operates from 27.8 to 143 Mc., covers both old and new FM bands and is the only commercially built receiver covering this range.

Further developments in this direction can soon be revealed—adding further support to Hallicrafters claim to continued supremacy in the high frequency field.



THE HALICRAFTERS CO., MANUFACTURERS OF RADIO
AND ELECTRONIC EQUIPMENT • CHICAGO 16, U. S. A.

COPYRIGHT 1945 THE HALICRAFTERS CO.

DEPENDABLE performance and durability of a Test Instrument is assured by its design and sturdiness of construction. All B. R. C. instruments are ruggedly built to give exacting and precise direct reading measurements with simplicity of operation.



Rugged construction of the 170-A Q Capacitor designed to maintain the high accuracy of the individually calibrated dial.

Q METER TYPE 170-A

This instrument embodies the general operating principles and characteristics of the 160-A Q-Meter but with such design and structural modifications as are required for accurate performance at higher frequencies. Has a frequency range of 30 mc to 200 mc.

Q METER TYPE 160-A—A standard for "Q" measurements with a reputation for accurate and dependable service. Has a frequency range of 50 kc to 75 mc which may be extended with external oscillator down to 1 kc.



BOONTON RADIO
Corporation



DESIGNERS AND MANUFACTURERS OF THE "Q" METER . . . QX-CHECKER . . . FREQUENCY MODULATED SIGNAL GENERATOR . . . BEAT FREQUENCY GENERATOR . . . AND OTHER DIRECT READING TEST INSTRUMENTS

Peacetime Development of New Weapons

(Continued from page 68A)

abroad. It was from the Bureau laboratories that the first successful radio fuze in the world was conceived and built.

Further interest in the selection of the National Bureau of Standards for this work is offered by the fact that *not only will the bureau study the applications of new scientific knowledge to war uses, but it will under-*



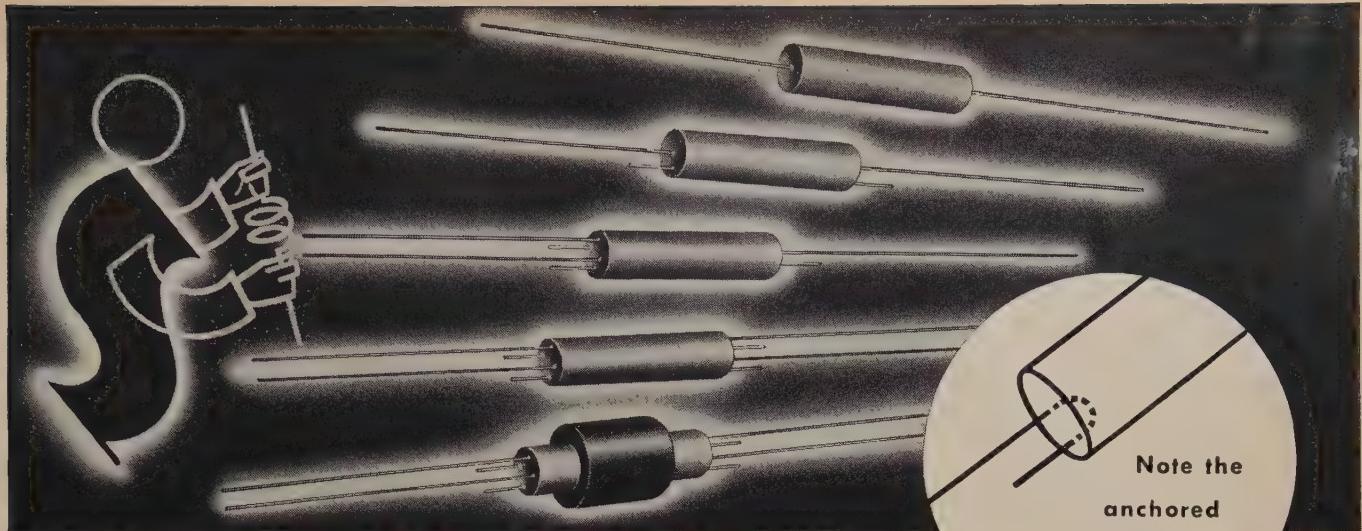
A. S. CLARKE

take the study of peacetime applications of the knowledge gained in the development of new weapons. So far as this information does not interfere with the safety of the United States and her Allies, the benefit of the new development will be made available to everyone. The National Bureau of Standards maintains widespread contacts with industry on new research and developments, new industrial processes, and new materials. Such contacts present fertile possibilities for translating current industrial advances into the electronic-ordnance art while, at the same time, bringing to industry the fruits of new developments resulting from long-term research on electronic-ordnance devices. Continuity of basic research at the Bureau in the new art of electronic ordnance which has sprung up during the war will lead to the development of new circuits and circuit components which will prove of benefit to industry. Particular examples are new radio tubes, miniature radio components, tiny high-powered electrical generators, mechanical and electronic controls, and new plastics.

To promote the organization of the best of facilities, the Ordnance Department arranged for the construction of a half-million dollar Ordnance Laboratory on the grounds of the National Bureau of Standards. Construction of the building began on May 8, 1945. At the cornerstone-laying ceremonies on July 23, 1945, General Campbell stressed the advantages that peacetime military research could afford not only to national security, but also to the promotion of the industrial economy.

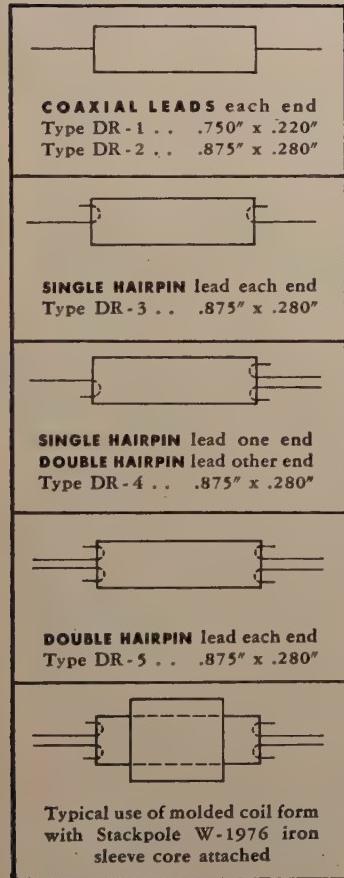
The work at the National Bureau of Standards will be centered in its Ordnance Development Division under the direction of Harry Diamond (A'26-M'30-SM'43-F'43). Several hundred physicists, engineers, and technicians will comprise the staff led by experienced scientists including Robert

(Continued on page 86A)



MOLDED COIL FORMS

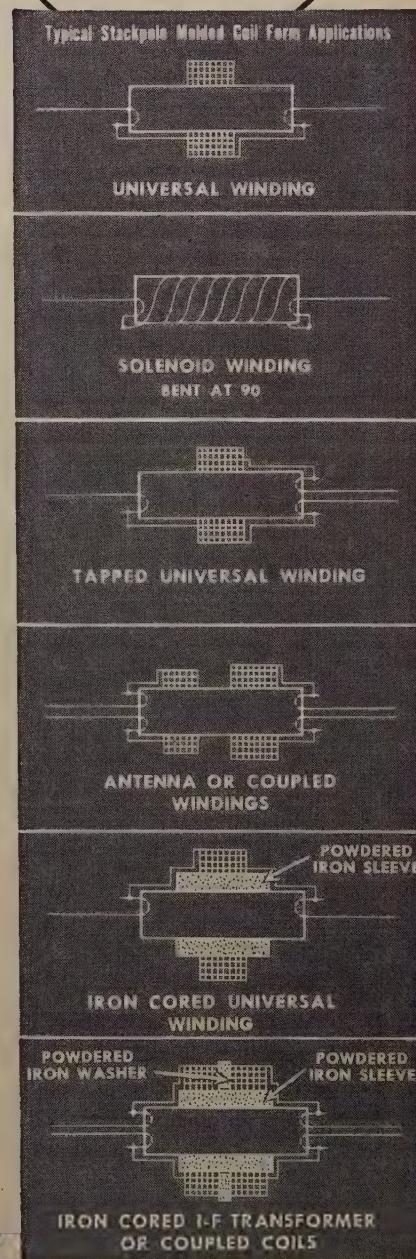
THE MODERN ANSWER TO INEXPENSIVE MECHANICAL SUPPORTS FOR WINDINGS



Reduced space factor . . . simplicity of assembly . . . point-to-point wiring . . . one third fewer soldered connections . . . extreme flexibility of application . . . absolute minimum cost

These proved advantages mean wide use for Stackpole molded bakelite coil forms in a variety of applications. Hairpin anchored leads mean that the soldered core wires are not disturbed or strained when leads are flexed or moved. The forms being smooth, coils may be wound on separate tubes and slipped over the forms—or windings may be wound directly on the forms. Where required, forms may be provided with Stackpole molded iron sleeve cores, thereby increasing Q materially, decreasing the amount of wire for a given inductance and reducing stray magnetic fields. Write for details or samples to meet your requirements.

STACKPOLE CARBON CO., ST. MARYS, PA.
Electronic Components Division



STACKPOLE

FIXED AND VARIABLE RESISTORS • IRON CORES • SWITCHES



MEANS MAXIMUM PERFORMANCE AT AN ECONOMICAL PRICE . . .

THERE is more to STANCOR design than theory and paper engineering. Behind-the-scenes operations reveal unremitting fact-finding—nothing is taken for granted. For the STANCOR engineer is as persistent as he is practical, demanding—and receiving—high standards of performance.

Engineering design implies more than mere conversion of the customer's electrical requirements to manufacturing specifications. At STANCOR it includes the employment, to the greatest advantage, of selected materials to achieve optimum performance—all with the constant practical thought—more useful watts per dollar.

Competent laboratory and sales engineering facilities are available NOW to meet your most exacting transformer specifications.



STANCOR
STANDARD TRANSFORMER CORPORATION
1500 NORTH HALSTED STREET CHICAGO 22, ILLINOIS

RESEARCH CORPORATION OFFERS
\$2,500,000 FOR POSTWAR
COLLEGIATE RESEARCH.

Scientists who made the atomic bomb, radar, and a host of other vital war weapons will have a chance to return promptly to college laboratories for scientific research and teaching through \$2,500,000 in grants offered to educational institutions by Research Corporation of New York, a non-profit organization devoted to advancing research and technology by use of revenues from inventions assigned to it by public-spirited inventors.

Preference in making these grants will be given, other factors being equal, to smaller institutions and those of more limited financial resources for research.

From 100 to 200 grants of \$2500 to \$5000 each year will be available in order that talented young scientists engaged, for the most part, in war research, in uniform or as civilians, will be able to undertake at universities and colleges research of peacetime importance in pure science, especially chemistry, physics, mathematics, and engineering.

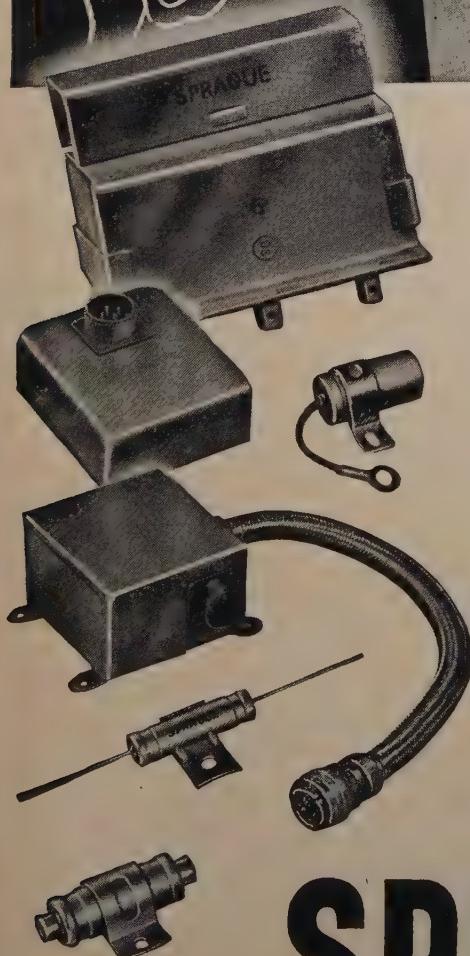
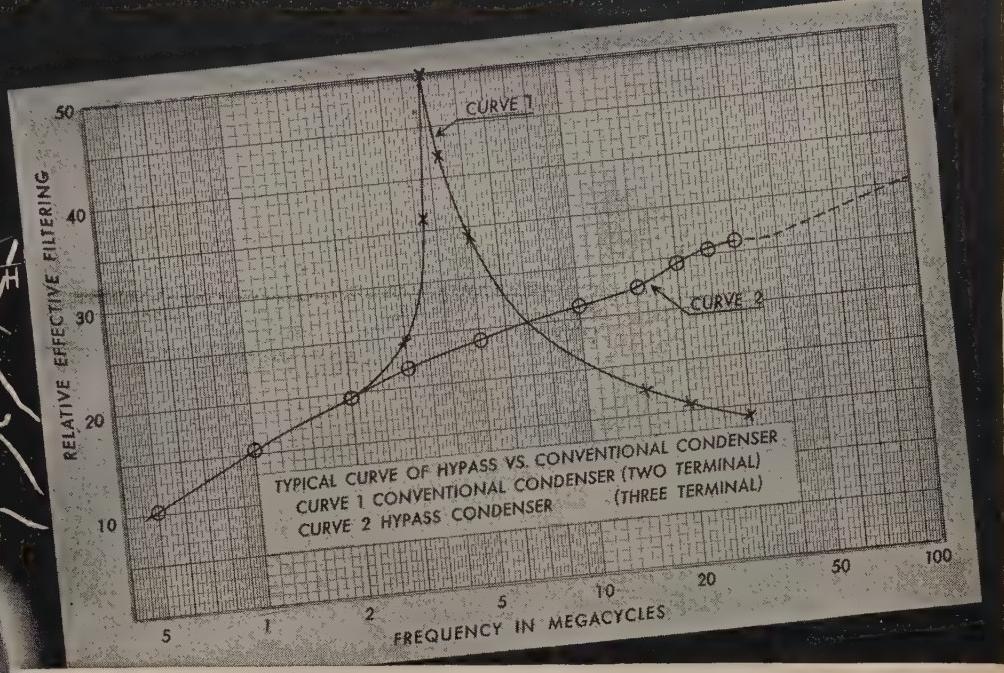
Grants will be made to the institutions at which the scientists will work and teach. The funds allotted will be available for the purchase of needed equipment and for employment of assistants either as Fellows or otherwise. Awards will be based primarily upon the demonstrated ability of the men who will conduct the researches and contribute to the teaching program of the school.

These special postwar grants will round out the plans that are being made for the most effective and most prompt return of the war-engaged scientists to peacetime fundamental and applied research. The Rockefeller Foundation has already announced a comprehensive plan of predoctoral fellowships which will return to college former graduate students who left their studies and researches for war research. Current government legislation and proposed bills being considered by Congress will aid the return to college of students whose scientific and technological education was interrupted by the war. Research Corporation grants will assist colleges in building research-minded staffs which will help train the students returning to colleges from the war, as well as the future contingents of students from our secondary schools in future years.

The grants are made possible by the fact that, during the war years, research programs that normally would be supported by Research Corporation grants have been laid aside in order to free men and facilities for war research.

To scientists of the Office of Scientific Research and Development, Army, Navy, and other war research agencies, the possibilities of these grants are being made known with an invitation to send applications to Dr. Robert R. Williams, Research Corporation, 405 Lexington Avenue, New York 17, New York.

RADIO INTERFERENCE?



**SPRAGUE HAS
the answers!**

From inexpensive noise suppression capacitors for automotive use, to heavy-duty designs for service on power equipment, and for current ratings from 5 to 200 amperes capacity, Sprague produces modern filter units for practically any need. An unsurpassed background of engineering experience in dealing with all types of radio noise interference problems, is here at your disposal. Write for Sprague Capacitor Catalog 20.

ANTI-RESONANT FREQUENCY PROBLEMS SOLVED

Have you a vibrator "hash" problem that a conventional by-pass capacitor shunted by a mica capacitor only partially solves?

If so, write for details on Sprague HYPASS Capacitors, the 3-terminal networks that do the job at 100 megacycles or more!

SPRAGUE ELECTRIC COMPANY
North Adams, Mass.

SPRAGUE

PIONEERS OF ELECTRIC-ELECTRONIC PROGRESS



5-Times Cited for
Distinguished
Wartime Service

Industrial Condenser Corporation's NEW HOME



THE WORLD'S MOST MODERN CONDENSER PLANT with these outstanding features

- ★ 1,000,000 VOLT RESEARCH LABORATORY
- ★ VERY LATEST PRODUCTION EQUIPMENT
- ★ SPECIALIZED WAR-LEARNED TECHNIQUES

From this NEW ultra-modern factory come capacitors carefully engineered and accurately produced. Staffed by skilled engineers and backed by 16 years of technical progress, Industrial Condenser Corp. is supplying capacitors for every application. If your specifications call for Electrolytic, Paper, Oil, or Motor capacitors, look to Industrial Condenser Corporation.

INDUSTRIAL CONDENSER CORPORATION

3243-65 NORTH CALIFORNIA AVENUE, CHICAGO 18, U. S. A.

District Offices in Principal Cities

PAPER, OIL AND ELECTROLYTIC MOTOR CAPACITORS

FUTURE OF RADIO COMMUNICATION AND ELECTRONICS

A vast system of radio relay stations, blanketing the entire country, carrying telephone and telegraph messages, broadcast programs, facsimile, and television simultaneously, was envisaged at Corpus Christi recently by Dr. C. B. Jolliffe, (M'25-F'30), executive vice-president in charge of RCA Laboratories, in an address on "The Radio-Electronic World of Tomorrow," delivered at the Naval Air Technical Training Center on Ward Island.

Pointing out that wartime research has greatly accelerated the normal progress of all branches of communications, Dr. Jolliffe mentioned radar, citizens' radio, electronic heating, and aviation radio as other fields that will become of increasing importance to the public in peacetime.

"Each of these new applications of radio," he said, "can create a new industry which will affect other industries. As the war approaches its conclusion, engineering developments and planning must be speeded up so that the trained men who come out of the armed services are not unemployed or their skills lost because it becomes necessary for them to take employment in other industries."

Discussing television, he said, "It does not take much imagination to see television as a possible five- or ten-billion-dollar enterprise, employing thousands of men and women, directly and indirectly. At the present moment all the instrumentalities are ready." Organization of television into a service, he added, needs the enthusiasm and imagination of creative thinking by young men who will not be stopped because of obstacles.

"It also needs the American spirit of enterprise which means pioneering by capital and industry, and encouragement by Government. Television should have the normal development of a new service, not hampered by unnecessary restrictions or limitations and not retarded by those who may not have the will to pioneer or the inclination to enter a new field now."

Dr. Jolliffe predicted wide application of radar to postwar aviation.

"Radio instruments," he said, "can look ahead, warn the pilot of obstacles and tell him at all times the altitude of his plane. Radio can make flying a safer and more reliable service; therefore it can be an important part of another great industry."

Recalling the many uses of handie-talkies and walkie-talkies by the armed forces, Dr. Jolliffe prophesied counterparts of these applications in peace:

"A farmer's wife can talk to her husband while he is on the tractor; a construction superintendent on a skyscraper give directions to his workers, a doctor can keep in touch with his office; a businessman can talk to his office even though he is in his car on the highway, in his airplane or on a train. The possible uses are as extensive as the human mind can imagine."

Discussing developments in ultra-high frequencies, Dr. Jolliffe pointed out that radio relays could do the job now being accomplished in the telephone and telegraph fields by wires.

"It is not fantastic," he explained, "to imagine long telephone and telegraph lines

(Continued on page 78A)

avoid damage from "in-the-package" moisture



no rust

**no corrosion
in this container**

SHIPPERS! Your product can be seriously damaged by rust, corrosion, or mildew . . . because of "in-the-package" moisture. Avoid such damage. Include Jay Cee Silica Gel, the ideal drying agent, in the packages with your product.

Your container may be sealed "tight as a drum" against outside moisture. Yet, the vapor within can cause untold harm. Particularly, a slight drop in temperature can release dangerous moisture.

Jay Cee Silica Gel keeps the air in the package dry . . . adsorbs the vapor . . . prevents moisture damage. Jay Cee Silica Gel is a crystalline substance resembling rock salt in general appearance . . . chemically inert. Has amazing power to take up moisture without its particles changing in size or shape. Packed in 1, 2, 4, 8 oz. and 1 and 5 lb. bags. Used widely with shipments of metal parts, precision instruments, electronic equipment, dehydrated foods, fabrics, and chemicals.



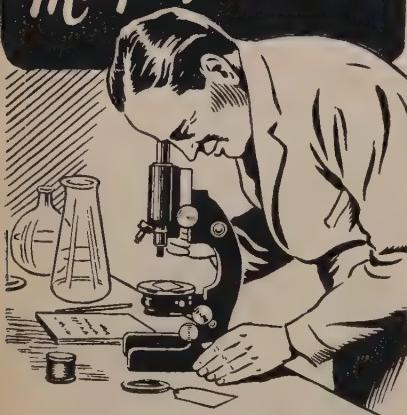
SILICA GEL

JOLIET CHEMICALS, LTD.
116 INDUSTRY AVENUE
JOLIET, ILLINOIS

The illustration shows Mr. Otto Mueller, packaging foreman, inspecting one of his Ampro Sound-On-Film Projectors sealed tightly within a representative moisture vapor-proof barrier, ready to be placed in a shipping carton. Packed within the barrier, with the Projector, are three small bags of Jay Cee Silica Gel . . . which adsorb "in-the-package" moisture and prevent damage from rust or corrosion.

(Cellophane packaging was used in this illustration as a substitute for the actual wrapping).

WOLLASTON Process Wire...So Fine it can be seen only under high magnification



We can draw wire as
small as

$\frac{1}{100,000}$ { of an inch
in diameter

... available in Platinum
and some other Metals

.00001" is less than 1/30 the
diameter of the smallest wire
die commercially available.
Yet our Wollaston Process
wire (drawn in a silver jacket)
closely meets your specifica-
tions for diameter, resistance
and other characteristics.

This organization specializes
in wire and ribbon of smaller
than commercial sizes and
closer than commercial toler-
ances. Write for List of Products.

SIGMUND COHN & CO.



44 GOLD STREET NEW YORK 7

FUTURE OF RADIO COMMUNICA- TION AND ELECTRONICS

(Continued from page 76A)

being replaced by lines of towers spaced 25 to 40 miles apart each equipped with small automatic radio transmitters and receivers carrying coast to coast many messages simultaneously over highly directive radio beams. A single line of radio relays can carry telegraph, telephone, and television or radio programs simultaneously with less maintenance or service than wire lines. Radio beams need no supports; maintenance problems are reduced to a minimum."

Another use of radio frequencies which promises great impact on industry," he said, "is in electronic heating." He mentioned the gluing of assemblies, hardening of surfaces, metal welding, and the speeding up of certain production processes such as the drying of penicillin, as established and successful applications of radio heat.

Turning to another phase of postwar technical work, Dr. Jolliffe emphasized that electronic research and development must be directed toward the prevention of another World War.

"In peacetime as well as in war" he stated, "research must be maintained on a wide basis in order to seek solutions of scientific problems from as many angles as possible. Research workers must be permitted to probe all fields freely and not be limited to fields which someone thinks may be useful to war or defense.

"America has a great reservoir of scientific talent—therein lies one of the greatest hope for the future of this country."

Membership

(Continued from page 64A)

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Stephenson, H. L., 582-5 St., Brooklyn 15, N. Y.

Stewart, E. C., 6023-34 St. N.E., Seattle 5, Wash.

Stone, R. L., Soundscriber Corp., 82 Audubon St., New Haven, Conn.

Swarthout, W. M., 789 E. 17 St., Brooklyn 30, N. Y.

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Thornley, R. F., 839 Fairfax Rd., Drexel Hill, Pa.

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Wladron, R. E., 55 Morgan St., Tuckahoe 7, N. Y.

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Weissenberger, E. G., 1096 Cherry St., Winnetka, Ill.

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Woodroffe, D. W., 675 Manukan Rd., Auckland, S.E. 3, New Zealand

Wrench, O., 726 Illinois St., Lawrence, Kan.

Yancovitz, M., 779 Shepherd Ave., Brooklyn 8, N. Y.



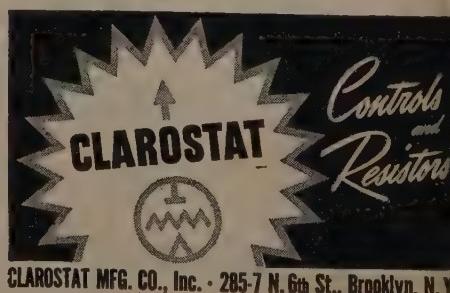
Sound-
System
CONTROLS

★ Clarostat offers an exceptional selection of sound-system controls. For instance, there is the Clarostat Constant - Impedance attenuator, Type CIB, illustrated above. It dissipates 10 watts at any setting. Used as output level control for power amplifiers, or as individual input attenuator for individual speakers. Linear up to 30 db in 10 steps, beginning at absolute zero, then 3 db steps to 24, then 30 db., and infinity.

Clarostat also offers L-pads, T-pads, faders and mixers, in widest range of resistance values, and in both the wire-wound and the composition-element types.

★ Submit your problem

If it has to do with sound-system controls or with controls, resistors or resistance devices, send it to us for engineering collaboration. Literature on request.



CLAROSTAT MFG. CO., Inc. • 285-7 N. 6th St., Brooklyn, N.Y.



HOW MYCALEX BUILDS BETTER PEACETIME PRODUCTS

As high frequency insulating standards become more exacting, the more apparent become the many advantages of MYCALEX over other types of materials . . . in building improved performance into electronic apparatus.

For 27 years MYCALEX has been known as "the most nearly perfect" insulation. Today improved MYCALEX demonstrates its superior properties wherever low loss factor and high dielectric strength are important . . . where resistance to arcing and high temperatures is desired . . . where imperviousness to oil and water must be virtually 100%.

New advancements in the molding of MYCALEX now make available the production of a wide variety of parts with metal inserts or electrodes molded in to create a positive seal.

It pays to become familiar with the physical and electrical properties of all three types of MYCALEX — MYCALEX 400, MYCALEX K and MYCALEX 410 (MOLDED). Our engineers invite your inquiries on all insulating problems.



TRADE MARK REG U S PAT OFF

MYCALEX CORPORATION OF AMERICA

"Owners of 'MYCALEX' Patents"

Plant and General Offices, CLIFTON, N. J.

Executive Offices, 30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y.

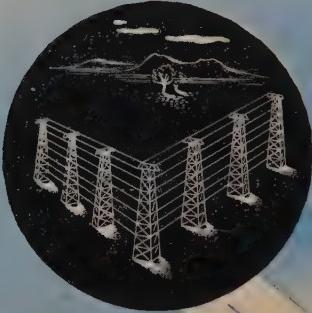
PROCEEDINGS OF THE I.R.E. AND WAVES AND ELECTRONS, June, 1946, Vol. 34, No. 6. Published monthly in two sections by The Institute of Radio Engineers, Inc., at 450 Ahnapee St., Menasha, Wis., or 330 West 42nd Street, New York 18, N.Y. Price \$1.00 per copy. Subscriptions: United States and Canada, \$10.00 a year; foreign countries, \$11.00 a year. Entered as second-class matter, October 26, 1927, at the post office at Menasha, Wisconsin, under the act of March 3, 1879. Acceptance for mailing at a special rate of postage is provided for in the act of February 28, 1925, embodied in Paragraph 4; Section 412, P. L. and R., authorized October 26, 1927.

Table of contents will be found following page 32A

Our THIS TEAM IS



1920 Loop antenna for 400-500 meter ship-to-shore radio telephone receivers. Its design enabled earliest measurements of field strength.



1929 Curtain antennas developed for beaming short-wave radio telephone messages to Europe and South America... improved commercial service.



1930 Half-wave vertical radiator, now in general use, was developed into practical form. It greatly improved signal output of broadcast stations.



1934 One of the first directional antenna arrays for broadcasting. Designed for WOR to concentrate signals in service area, eliminate radiation over ocean.

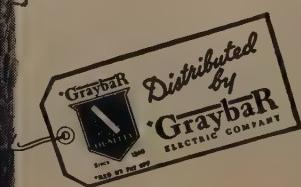


1938 Coaxial antenna for ultra high frequency communications, designed by Bell Laboratories, gave increased signal strength. Widely used in police radio systems.



1941 Polyrod radar antenna was an important war contribution... helped sink many Jap ships. Its exceptionally narrow beam and rapid scanning gave high accuracy to big Navy guns.

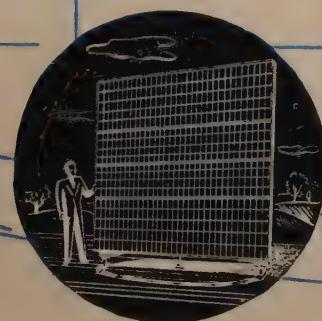
1946 New 54A CLOVER-LEAF FM broadcast antenna has high efficiency and a circular azimuth pattern; is simple to install and maintain. May be used for any power level up to and including 50 KW.



Up ON ANTENNAS



1930 Rhombic (diamond-shaped) antenna for 14-60 meters. It covers wide frequency range without adjustment. Still standard for this band.



1944 Metal lenses, another Bell Laboratories development, focus microwaves like light. One type has a beam width of only 0.1°—or less than that of a big searchlight.

As pioneers and leaders in radio, Bell Telephone Laboratories and Western Electric have been vitally concerned with the development of improved antennas for more than 30 years.

From the long-wave days of radio's youth, right through to today with its microwaves, this team has been responsible for much of the progress in antenna design.

Progress based on Research

Following their long-established method of attack, Bell Laboratories scientists are continually observing, investigating and measuring the action of radio waves in space. Their research has covered wave lengths ranging from hundreds of meters to a fraction of a centimeter. In over a quarter-century of intensive study, they have learned how radio waves behave, day and night, under all sorts of weather conditions.

Out of this fundamental research have come such outstanding developments as the rhombic antenna, musa antenna, vertical half-wave radiator, curtain antenna, directional array, the polyrod and other improved radar antennas, the metal lens for microwaves and the new CLOVER-LEAF antenna for FM broadcasting.

What this means to YOU

Whether you are interested in AM or FM—equipment for broadcasting, point-to-point, aviation, mobile or marine use—here's the thing to remember. Every item of radio apparatus designed by Bell Laboratories and made by Western Electric is backed by just such thorough scientific research as has been given to antennas. It's designed right and made right to give you years of high quality, efficient, trouble-free service.



BELL TELEPHONE LABORATORIES

World's largest organization devoted exclusively to research and development in all phases of electrical communications.

Western Electric

Manufacturing unit of the Bell System and the nation's largest producer of communications equipment.



Newest

v-h-f power triode for FM and TELEVISION

**TYPE
GL-9C24
TRANSMITTING
TUBE**



RATINGS

Filament voltage	6.3 v
Filament current	250 amp
Grid-plate transconductance	11,000 micromhos
Interelectrode capacitances:	
Grid-filament	23 micromicrofarads
Grid-plate	15 micromicrofarads
Plate-filament	0.7 micromicrofarads
Type of cooling	water and forced air
Plate ratings per tube, Class B r-f power amplifier (video service, synchronizing peak conditions):	
Max voltage	5,000 v
Max current	2 amp
Max input	10 kw
Max dissipation	5 kw
* Useful power output, typical operation (at 4,000 v and 1.7 amp, band width 5mc)	3.4 kw
Plate ratings per tube, Class C r-f power amplifier (key-down conditions without modulation):	
Max voltage	6,500 v
Max current	2 amp
Max input	12 kw
Max dissipation	5 kw
* Useful power output, typical operation (at 6,000 v and 1.3 amp)	6.4 kw
*Includes power transferred from driver to output of grounded-grid amplifier.	

GENERAL ELECTRIC'S great new power tube for FM and television—Type GL-9C24—combines high power output at very-high frequencies with unexcelled advantages of design. This is the tube you want and need, for the power amplifier stages of new transmitters now on your drawing boards!

In FM use, a pair of GL-9C24's, operating conservatively, will put out more than 10 kw of power. In television, broad-band tests prove that a pair easily will deliver in excess of 5 kw at synchronizing peak level.

No neutralization is required when GL-9C24's are employed in a properly designed line or cavity type of

grounded-grid amplifier—the circuit to which this tube is particularly adapted. Other features: . . . Lead inductance is extremely low. All external metal parts are silver-plated, to reduce r-f losses and provide better electrical contact surfaces. Fernico metal-to-glass bonds are used throughout. Ring-seal design gives large terminal-contact areas, with correspondingly improved efficiency.

G-E tube engineers are ready to work closely with you on the application of this new v-h-f tube to your new FM and television transmitters. Phone your nearest G-E office, or write the Electronics Department, General Electric Company, Schenectady 5, New York.

GENERAL ELECTRIC

FIRST AND GREATEST NAME IN ELECTRONICS

Receiving Diversity Tone Keyer

Designed, Engineered

and Built to Work

for the World's Most

Critical Employer . . .

MODEL R-626



The International Press

It's to the credit of Press Wireless that its international communications systems and their components have for a decade and a half stood up to the task of delivering the tens-of-thousands of words of vital, high speed radio communications traffic daily demanded by the press of the world.

The R-626 Tone Keyer, like all other Press Wireless developed equipment, has been carefully designed by experienced engineers; the men who for years have been charged with the responsibility of planning, installing and operating the vast array of equipment which makes up the Press Wireless international radio press circuits.

R-626 RECEIVING
DIVERSITY TONE KEYER
CHARACTERISTICS

- Connections for diversity receiver operation
- Multiple fixed-frequency receiving feature
- High keying speeds better than 1000 w p m
- Constant amplitude keyed audio output to + 20 vu
- Input requires minimum of only 1 volt from 2nd detector of one or more receivers.
- Output selectable for anyone of 6 standard filter tones
- Reduced keying bias with front panel "shaper" control
- I-F Monitor circuit for precise receiver i-f adjustment
- Built-in, 110 volt, 50/60 cycle power supply
- Standard 19-inch rack mounting



PRESS WIRELESS MANUFACTURING

C O R P O R A T I O N

Executive Offices: 38-01 35th AVENUE, LONG ISLAND CITY 1, NEW YORK



CABLES

For Use in Transmission of High Frequencies

CONNECTORS

- Amphenol Twinax and Coax RG cables, produced to standards that surpass the high Army-Navy specifications for critical wartime uses, are ideal for the myriad of peacetime applications in all phases of the rapidly expanding electronic industries. Rigid laboratory tests and notarized affidavits on every shipment give final assurance of extra quality and dependability.
- Amphenol special low-loss V.H.F. connectors are available in a complete line for all practical applications of RG cables and other uses. Mechanically efficient and electrically correct, these easily assembled connectors and adapters provide the utmost efficiency in circuits in which they are used.

AMPHENOL ASSEMBLY SERVICE

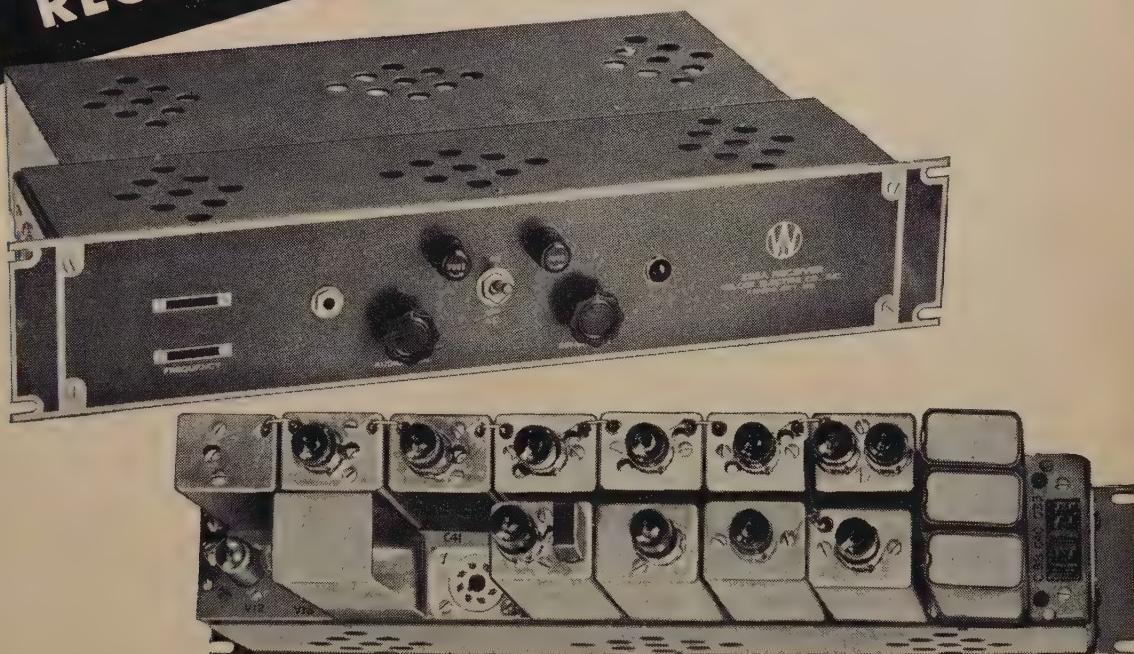
An important part of Amphenol service to users of cables and connectors is a complete Assembly Service. Rigid specifications and performance requirements, plus thorough scientific testing of each part and process, assures users of satisfactory service. For cables, connectors and complete assembly service, look to the world's largest producer - Amphenol.

AMERICAN PHENOLIC CORPORATION
CHICAGO 50, ILLINOIS
IN CANADA
AMPHENOL LIMITED • TORONTO



COAXIAL CABLES AND CONNECTORS • INDUSTRIAL CONNECTORS, FITTINGS AND CONDUIT • ANTENNAS • RADIO COMPONENTS • PLASTICS FOR ELECTRONICS

THE WILCOX TYPE 255A RECEIVER



A new fixed frequency receiver to meet the present and future requirements of aeronautical ground-air, or point-to-point radio communications.

With increased traffic and new services taxing the already over-crowded 2-20 Mc communication frequencies, the Wilcox Electric Co. Type 255A Receiver has been especially engineered to minimize adjacent channel interference, and to maintain good intelligibility on telephone reception.

The Type 255A occupies only 3½ inches of rack space, making it readily adaptable to the replacement of existing receivers.

- Input Impedance: 70 ohms.
- Output Impedance: 500 ohms, center-tapped.
- Power: 110 V.A.C., 50-60 cycles, 60 watts.
- Output Power: Choice of 50 milliwatts or 1.25 watts.
- Sensitivity: 1 microvolt at 2/1 SN ratio.
- Spurious Frequency Response: 80 D.B.
- A.V.C.: 3 DB variation from 10 microvolts to 1.5 volts.
- Selectivity: 2X-2 Kc. wide.
10X-4 Kc. wide.
100X-7 Kc. wide.
1000X-11 Kc. wide
- Size: 3½" H. x 19" W. x 11½" D.

Detailed information on request.

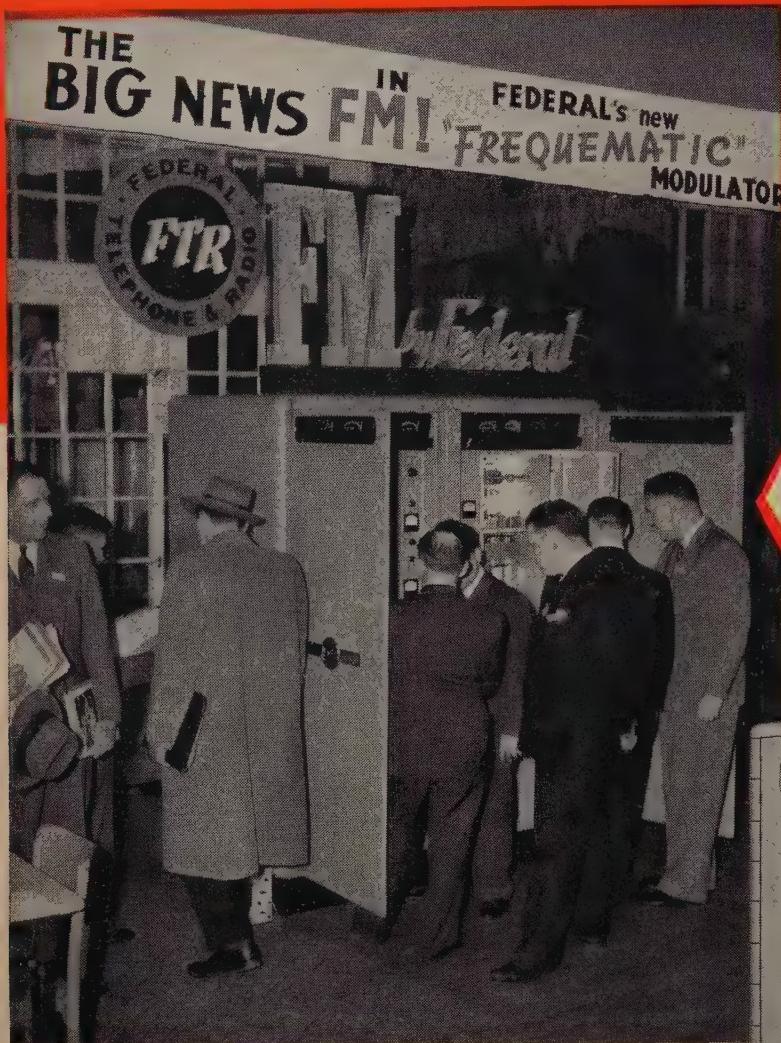
Use of miniature tubes permits the building of each stage of the receiver complete within its own shield can, which in turn, plugs into an octal tube socket on the chassis.

Thus, each stage is instantly removable for maintenance, and may be checked in a test set similar to those used for vacuum tubes. Maintenance may then be accomplished on the bench, or a spare stage plugged in, and the stage returned to a maintenance base.



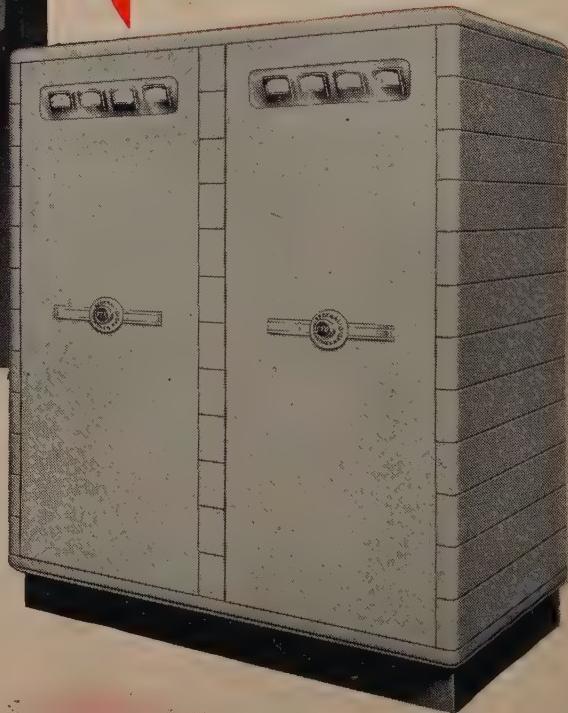
**WILCOX ELECTRIC
COMPANY, INC.**

Manufacturers of Radio Equipment
**FOURTEENTH AND CHESTNUT
KANSAS CITY, MISSOURI**



FEDERAL'S ... and

Here's Federal's 1 Kw FM transmitter that stole the show at the sixth annual Broadcast Engineering Conference at Ohio State University. A group of engineers are shown examining the equipment in actual operation at the conference.



Federal Features for Better FM



Federal's new "FREQUEMATIC" FM modulator—a radically improved type of modulator-oscillator unit—gives FM transmission outstanding fidelity and mean-carrier stability, with unsurpassed dependability and economy.



By means of simple all-electronic circuits, "FREQUEMATIC" maintains the center-frequency stability within a tolerance of plus or minus one thousandth of one per cent of the assigned value—only half of the present FCC tolerance requirement.



Remarkable noise-level reductions resulted in an actual measured signal-to-noise ratio of 5600 to 1—a level so low that Federal had to build special test equipment for its measurement.



Undistorted modulation of all audio signals between 50 and 15000 cycles is maintained, even when the transmitter is over-modulated as much as three hundred per cent by transient passages.



This outstanding performance is obtained with simple circuits and standard receiver tubes, and the equipment depends mainly on resistances and capacitances for critical and non-critical functions.



Another feature—of special interest to all broadcasters—is the extreme ease of initial alignment and operational maintenance. The unit can be completely tuned in a matter of minutes, as only two tuning operations are necessary. There are no tuned circuits in the crystal oscillator or frequency divider networks.



New high-efficiency, air-cooled and water-cooled tubes, developed by Federal, are employed in the power amplifier stages of the transmitter, contributing to long life, stable operation and low noise level.

Federal

FM STEALS THE SHOW

orders are being filled now!

1, 3, 10, 20, 50 Kw FM TRANSMITTERS
featuring the new

"FREQUEMATIC"*

MODULATOR

FCC GIVES
GREEN LIGHT
TO FM

COLUMBUS, OHIO. When the Federal Communications Commission started issuing engineering authority for new high-power FM broadcast stations, it acted wisely in the national interest both from the standpoint of the radio industry and the listening public, it was declared by Norman E. Wunderlich, executive sales director, Federal Telephone and Radio Corporation, in a statement here while attending the sixth annual Broadcast Engineering Conference held at the Ohio State University.

Not only has the FCC, by its action, set the industry in motion for the manufacture of frequency modulation transmitting equipment and receivers, but it has assured the listening public of the finest of high-fidelity reception, Mr. Wunderlich stated. He added that the Commission should be warmly ap-

Federal's display of FM transmitting equipment, in actual operation at the sixth annual Broadcast Engineering Conference, created a real sensation among the country's foremost broadcast engineers. The new "FREQUEMATIC" modulator, an exclusive feature of Federal's 1, 3, 10, 20, 50 kw transmitters, made big news—exceeding the exacting requirements of the FCC Standards of Good Engineering Practice on every technical point. Of outstanding importance, too, is the fact that this new FM equipment is in actual production now!

Federal is ready to provide your new FM station with the finest transmission equipment available—complete in every detail, from microphone to transmitting tower. This outstanding "one-source" service means completely matched components for the entire system—all precision engineered, all of highest quality, all designed to work together as a single, perfected and coordinated FM system.

Federal gives complete service, too. Federal will provide a factory-trained radio engineer to supervise the installation, tune up the equipment, and to instruct your personnel in its operation and maintenance—all without extra charge. Federal will also assist in obtaining CPA approval for any new buildings or construction work required for the FM transmitter equipment.

For complete information, write: Federal Telephone and Radio Corporation, Newark 1, New Jersey.

*Trade Mark

Telephone and Radio Corporation

Export Distributor:
International Standard Electric Corporation

Proceedings of the I.R.E. and Waves and Electrons

June, 1946

Newark 1, New Jersey



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THE initials "CRL" in the diamond represent the research-laboratory and technical manufacturing facilities of Centralab . . . a name outstanding for quality, precision and new developments in the field of radio and electronics.

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Centralab



Division of GLOBE-UNION INC., Milwaukee

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Ceramic Trimmers
Bulletin 695



Ceramic High Voltage Capacitors
Bulletin 814



Variable Resistors
Bulletin 697



Tubular Ceramic Capacitors
Bulletins 630 and 586

Selector Switches
Bulletin 722

MAKING TUBES IS EASY If you know how!



This standardized Hytron production tester is composed of three units: preheater, characteristics tester, noise tester. To permit a better view of the equipment, only one of three operators is shown.

HOW THE HYTRON 12SK7GT IS QUALITY CHECKED

Test	100% Production Test	Central Inspection Sampling	Quality Laboratory Sampling	100% Test at Packing
Shorts	x	x	x	x
Base shell connection	x	x	x	x
Heater current	x	x	x	x
Plate current	x	x	x	x
Screen current	x	x	x	x
Grid current	x	x	x	x
Transconductance	x	x	x	x
Suppressor action	x	x	x	x
Emission	x	x	x	x
Heater-cathode leakage	x	x	x	x
R-f noise	x	x	x	x
Transconductance cutoff	x	x	x	x
Vibration	x	x	x	x
Insulation resistance	x	x	x	x
Input capacitance	x	x	x	x
Output capacitance	x	x	x	x
Grid-plate capacitance	x	x	x	x
Grid emission	x	x	x	x
Immersion (basing cement)	x	x	x	x
Life	x	x	x	x
Overall length	x	x	x	x
Mechanical*	x	x	x	x

*Mechanical tests are covered by a multipage specification. Typical inspection is conducted visually and/or by gages for the following: pin solder, etching, getter flash, diameter, base-bulb alignment, bent base pins, glass defects, and rigidity of internal elements, bases, and base pins.

AGAIN HYTRON'S LONG EXPERIENCE

GIVES YOU THE BEST...

FOR your protection Hytron tubes are quadruple-checked. On the production floor, each tube is first tested for significant characteristics. In the central inspection department, a random sampling is next taken for statistical control of the production testing—to assure quality within acceptance limits. Failure at this point demands 100% retest.

Daily a smaller random sampling is subjected to a searching design check of characteristics such as inter-electrode capacitances, grid emission, and transconductance cutoff. These characteristics can be controlled by the smaller sampling, and their testing requires laboratory precision. Simultaneously production tests are again repeated for further statistical control. Again failure to meet acceptance limits demands 100% retest—even for design characteristics not production-tested.



Extreme accuracy and flexibility of this Hytron master test station particularly fit it for quality control.

Finally each tube is once more short-tested and mechanically inspected just before packing.

This painstaking quadruple-checking ensures that specification failures of tubes actually shipped will be a practically irreducible minimum. When you buy a Hytron tube, you can be certain that every ounce of Hytron know-how on quality control—reinforced by wartime experience—has been in there punching to give you only the best.

OLDEST MANUFACTURER SPECIALIZING IN RADIO RECEIVING TUBES



HYTRON

RADIO AND ELECTRONICS CORP.



MAIN OFFICE: SALEM, MASSACHUSETTS

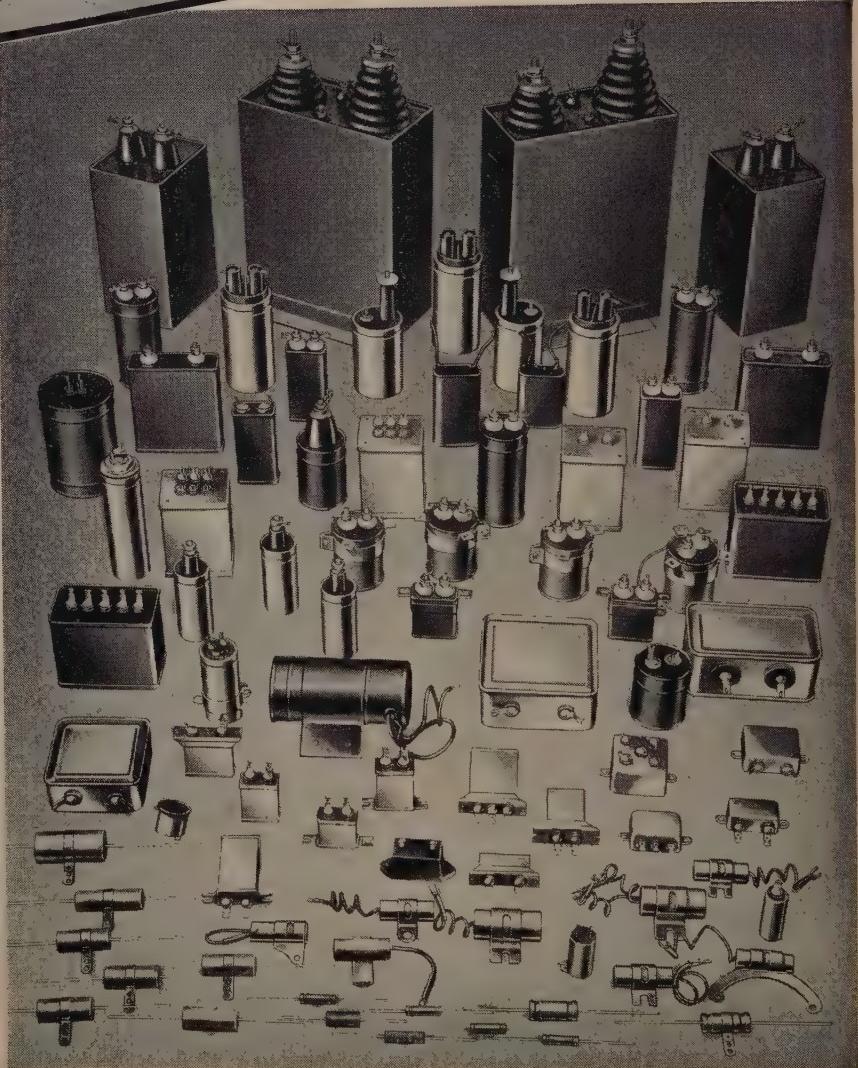
A TYPE FOR Every APPLICATION OIL-FILLED CAPACITORS

- Functionally fitted to given application—that's the keynote of the extensive Aerovox oil-filled capacitor line. A plentiful selection of containers, mountings, terminals, sizes and impregnants, assures virtually custom-built capacitors with guaranteed performance.

Aerovox offers both Hyvol and Hyvol-M (mineral oil) liquid impregnants. For applications subjected to wide temperature variations, and where weight and size are important, Hyvol is recommended. Hyvol capacitors are considerably more constant with temperature variations than are those with other impregnating materials of the same specific inductive capacity, showing no capacitance drop until temperatures of -20° F. (-29° C.) are reached. At -40° F. (-40° C.) the maximum capacitance drop that may be expected is of the order of 5 to 10%.

Hyvol-M (mineral oil) capacitors have an exceptionally flat temperature coefficient of capacitance curve but approximately 35% greater bulk and corresponding weight which usually rules them out in favor of Hyvol.

At any rate, Aerovox offers both Hyvol and mineral oil capacitors, as well as wax-impregnated units for limited service—along with that wide choice of containers, mountings, terminals—to meet your exact needs.



- NEW CATALOG** lists the exceptionally wide selection of Aerovox oil capacitors, as well as other types. Write on business letterhead for registered copy available only to engineers, designers, electronic maintenance men, manufacturers of equipment, and executives.

FOR RADIO-ELECTRONIC AND INDUSTRIAL APPLICATIONS

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PRESTO

MODEL "L"



A better portable playback—compact, easy to carry, simple to set up. The remarkably clear, wide range of reproduction—far superior to what is ordinarily expected of a portable playback—makes it a favorite with broadcasting stations and advertising agencies who demand top performance in demonstrating recorded programs to prospective clients.

Model L plays 6 to 16" records, 78 or 33½ R.P.M., on a 12" rim-driven turntable. Standard equipment includes high quality 16" pickup on a swivel mounting which folds into a case when not in use, four stage amplifier, 8" loudspeaker with 20' extension cable, and a Presto Transcriptone semi-permanent playing needle. For use on 110 volts AC only.

The complete equipment, in an attractive grey carrying case, weighs only 46 lbs.

PRESTO

RECORDING CORPORATION

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WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT

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Other High-Voltage Resistor
Applications...

**10,000 VOLTS
BREAKDOWN
from STANDARD
Sprague Koolohm
Resistor to Ground**



Completely insulated surface

Standard Sprague Koolohm Wire Wound Resistors have the high insulation resistance to ground which you need for television and other applications where high voltages are involved—*10,000 volts from the surface of their sturdy ceramic jackets to their resistance elements*. Mount them anywhere without fear of voltage breakdown!

In addition, Koolohms give you the advantages of higher resistances in smaller physical sizes; easier mounting; use at full wattage ratings; and overall tropicalized protection against the most severely humid conditions. Write for Catalog 10EA.



SPRAGUE ELECTRIC CO., Resistor Division, North Adams, Mass.



SPRAGUE KOOLOHMS

TRADEMARK REGISTERED U.S. PAT. OFF.

The Greatest Wire-Wound Resistor Development in 20 Years

ALL ABOUT THE NEW "EVEREADY" "A-B" PORTABLE BATTERY

FOR 1.4 VOLT
RECEIVERS

THIS IS THE FIRST "A-B" portable battery pack to include a "B" section constructed on the basis of National Carbon Company's exclusive flat-cell principle. With this construction, you get longer life than that available from batteries of similar size using round or "can" type cells.

This new battery, the No. 754, is a 9 volt-90 volt pack. Drawing shows the overall dimensions, socket arrangement, and socket location. The cell content and service life for the No. 754 pack are the same as for the popular pre-war battery complement consisting of 2 No. 746 4½ volt "A" batteries and 2 No. 482 45 volt "Eveready" "B" batteries.

SPECIFICATIONS...

WEIGHT	6½ lbs.
DIMENSIONS.....	Drawing shows maximum dimensions with tolerances as indicated.
SOCKET.....	7½ V — 9V — 90V R.M.A. Standard.
CELLS—"A" SECTION.....	6 "G" size cells connected in series with tap at 7½ volts.
"B" SECTION.....	60 No. 165 flat type cells connected in series.
VOLTAGE TAPS.....	— A, + 7½ A, + 9 A, — B, + 90 B.
MATCHING PLUG FOR SOCKET...	Cinch Mfg. Co. No. 2901, or equivalent, provides connection to — A, + 9 A, — B, + 90 B. Plugs including connection to + 7½ A have not been announced as yet.

CIRCUIT APPLICATION. The "A" section provides radio receiver designers with maximum flexibility in choice of tube complements. Using series connected tubes with filaments rated at 50 m.a. at 1.4 volts or 50 m.a. at 2.8 volts, at least seven different circuits are suggested. Table 1 is presented to illustrate filament combinations that might be used with the No. 754 pack. One of the seven suggested combinations should provide the designer with his particular requirements insofar as balance between radio frequency sensitivity and power output is concerned.

TABLE 1

TUBE FUNCTION	VACUUM TUBE FILAMENT COMBINATIONS						
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
R. F. Amplifier	1.5	1.5	—	—	1.5	—	—
First Detector	1.5	1.5	1.5	1.5	1.5	1.5	1.5
I. F. Amplifier	1.5	1.5	1.5	3.0	1.5	1.5	1.5
I. F. Amplifier	—	1.5	1.5	—	—	—	1.5
Second Detector	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Audio Output	3.0	1.5	3.0	3.0	1.5	3.0	1.5
Total "A" Voltage	9.0	9.0	9.0	9.0	7.5	7.5	7.5

SERVICE ESTIMATES. It is impossible to predict how long batteries will last in the user's hands. Fairly accurate service estimates can be established, however, if initial current drain, hours of use per day, and end point voltage are specified. Assuming an operating schedule of four hours per day, Table 2 has been calculated to provide designers with sufficient information to indicate the magnitude of allowable "B" drain that will result in balanced "A" and "B" life. It is good engineering practice to aim at somewhat longer "A" life than "B" life. This will insure most economical operations since the "B" section of "A-B" packs is the more expensive section, and it is in the user's interest to take full advantage of the available "B" voltage.

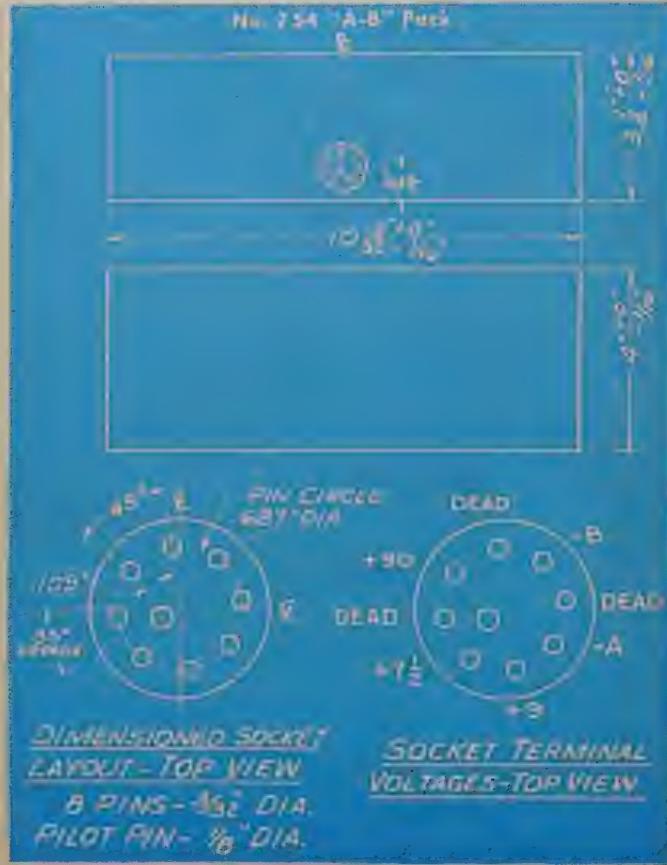


TABLE 2

SERVICE ESTIMATES—No. 754 "A-B" PACK— USED FOUR HOURS PER DAY			
INITIAL "A" DRAIN 50 m.a.	SERVICE TO*		
	6.6 Volts	6.0 Volts	
200 Hours	225 Hours		
SERVICE TO			
INITIAL "B" DRAIN	68 Volts	60 Volts	48 Volts
10 m.a.	210 Hours	260 Hours	330 Hours
12 m.a.	160 "	200 "	260 "
15 m.a.	120 "	150 "	200 "

* To 5.5 volts and 5.0 volts, respectively, for 7.5 volt tap.

Most portable radio receivers maintain adequate sensitivity, oscillator stability, and power output over a "B" voltage range from 90 to 60 volts. In the best designs, the "B" battery is usable down to 48 volts.

NEED ANY HELP? Engineers at National Carbon will be glad to consult with you on any battery problem. Write today.



NATIONAL CARBON COMPANY, INC.

30 East 42nd Street, New York 17, N. Y.
UNIT OF UNION CARBIDE AND CARBON CORPORATION



WATCH FOR IT!

DU MONT'S new 5-INCH OSCILLOGRAPH

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COMPARES FREQUENCIES • ANALYZES PERFORMANCE • SHOWS CIRCUIT FUNCTIONS

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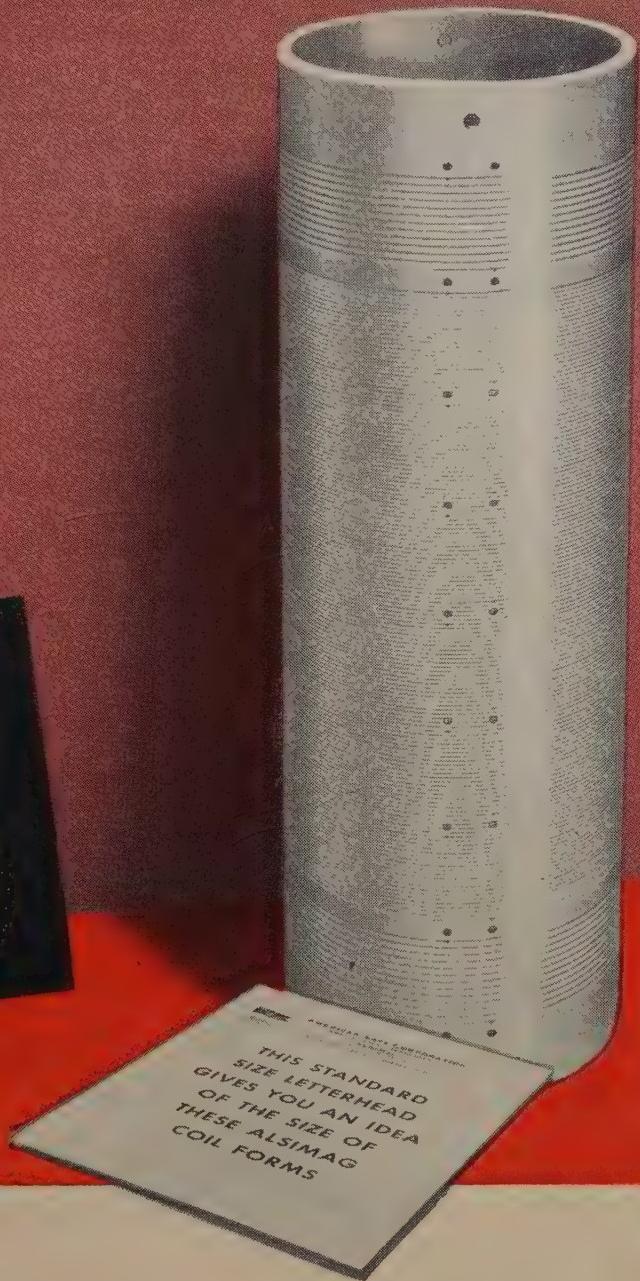
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\$99⁵⁰

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only at American Lava Corporation.

Your request will bring property charts which give physical characteristics of the more frequently used AISiMag compositions. If your requirement demands special or unusual characteristics, the developmental laboratory may find exactly those characteristics in its research records, or develop them quickly for you.

ALSiMAG
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These large, thin walled, coil forms (machined to close tolerances) are an example of American Lava Corporation craftsmanship in technical ceramics.

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ENGINEERING SERVICE OFFICES:

Original Award July 27, 1942
Second Award February 13, 1943
Third Award September 25, 1943
Fourth Award May 27, 1944
Fifth Award December 2, 1944

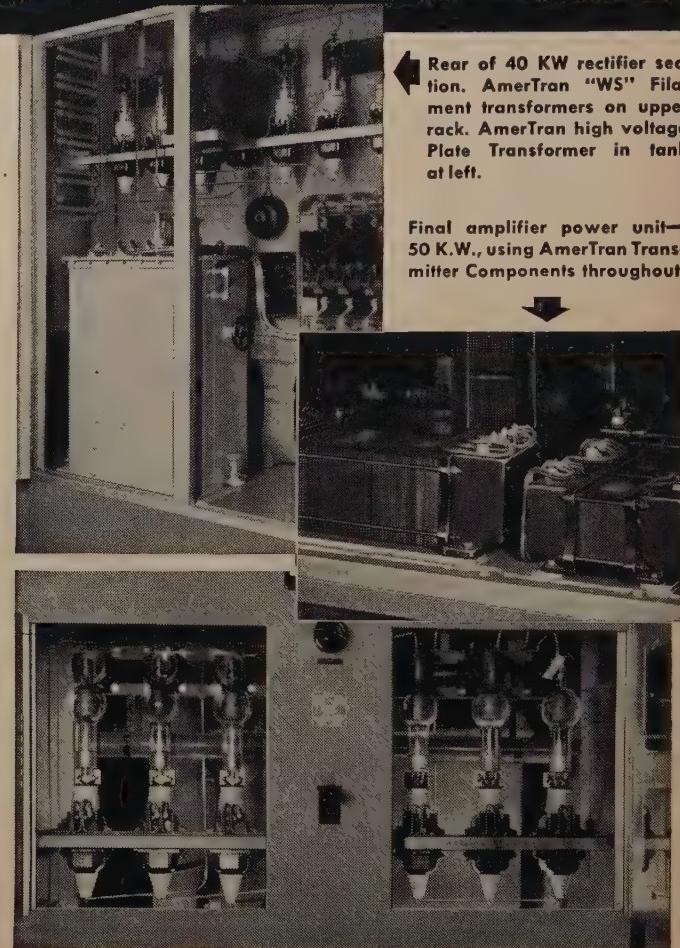
AMERTRAN TRANSFORMERS

"Take a Bow" in the New, Compact PRESS WIRELESS TRANSMITTERS

THE new series Press Wireless Transmitters are trim, powerful, and clean as a hound's tooth. This batch is for Naval use (40 to 50 K.W.) built by Press Wireless Manufacturing Corporation at their Hicksville, Long Island factory. As the photos prove, AmerTran transformers and reactors sort of "steal the show" in these units. There's a reason. Press Wireless, Inc., the communications part of the Press Wireless organization, have been using AmerTrans for many years — in the powerful stations they operate for world-wide radio coverage. They like the characteristics and endurance of AmerTrans, and are kind enough to say so.

AmerTran Transformers are designed by authorities in electronic energy transformation. They are built in a plant devoted exclusively to the production of transformers and allied products. The entire AmerTran organization is available to help you get the most up-to-date, efficient performance for your transformer dollar. That is why AmerTran products are built-in components in the best-known communications and industrial-electronic assemblies now in operation.

Bulletin "G" shows the wide scope of AmerTran products. We'll be glad to send you a copy.



Rear of 40 KW rectifier section. AmerTran "WS" Filament transformers on upper rack. AmerTran high voltage Plate Transformer in tank at left.

Final amplifier power unit—50 K.W., using AmerTran Transmitter Components throughout.

Front panel view, rectifier section, showing AmerTran Filament Transformers.

An Amer-Tran development—The Type "WS" integral Filament Transformer. Used by leading transmitter manufacturers. Short leads, space-saving design.

AmerTran 8,000 V. Plate Transformer. "WS" Filament Transformers visible at right.



AMERICAN TRANSFORMER CO.

178 EMMET ST., NEWARK 5, N. J.

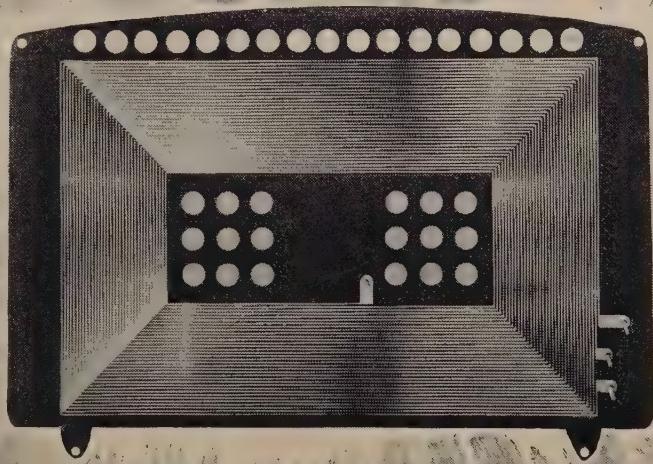


Pioneer Manufacturers of Transformers, Reactors and Rectifiers for Electronics and Power Transmission

AMERTRAN

REG. U.S. PAT. OFF.
MANUFACTURING SINCE 1901 AT NEWARK, N.J.

COPPER is the "Metal of Invention"



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The Franklin Airloop Corp., 175 Varick St., New York 14, N. Y., makes this unique antenna to set manufacturers' specifications.

It is Revere copper that makes possible the unusual Franklin Airloop antenna. This is die-stamped out of .005" sheet, a single operation on automatic machines forming the loop and locking it into the backboard. The result is superior ruggedness, less distributed capacity, higher "Q," and lower cost.

Thus copper once again proves that its unique qualities make it "The Metal of Invention." Easy workability, high electrical and heat conductivity, corrosion resistance, availability in a variety of tempers and in sheet, strip, plate, bar and rod—copper by Revere serves the radio industry in many different ways.

Revere also offers copper alloys, aluminum and magnesium, and electric welded steel tube. Selection of the proper metal or alloy may at times be a matter for careful study; Revere is always glad to cooperate with engineers, designers and production men in working out the most economical and efficient applications.

REVERE PRODUCTS INCLUDE

Copper and Copper Alloys in sheet and plate, rolls and strip, rod and bar, tube and pipe, extruded shapes, forgings.

Aluminum Alloys in tubing, extruded shapes, forgings.

Magnesium Alloys in sheet and plate, rod and bar, tubing, extruded shapes, forgings.

Electric Welded Steel Tube in straight lengths or semi-fabricated to your designs.

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Founded by Paul Revere in 1801

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Sales Offices in Principal Cities, Distributors Everywhere.

Listen to *Exploring the Unknown* on the Mutual Network every Sunday evening, 9 to 9:30 p.m., EDST.

RAYTHEON

Standardized

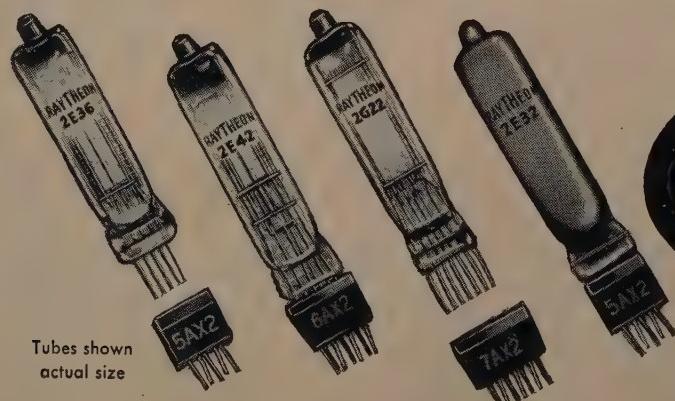
SUB-MINIATURE TUBES

FIRST DEVELOPED TO BE SHOT FROM GUNS—
NOW DESIGNED FOR RADIO RECEIVER USE

In October, 1940, Raytheon was the first tube manufacturer to take an NDRC contract to develop tubes for the Proximity Fuze project. In March, 1941, these tubes were successfully shot from guns and the Fuze project was established as being practical and effective. Late in 1941 Raytheon contributed a basically improved type of filament suspension which has since been employed in all vacuum tubes for the VT Fuze.

Since VT Fuzes could be used but once, the tubes were soldered in directly. This method is uneconomical for radio applications. With this in mind, Raytheon then developed a plug-in feature and low-loss socket which allows all the space-saving which characterizes these tubes. Today there are four basic types in the Raytheon line of sub-miniature tubes—all specifically designed for low-voltage radio receiver applications. Standard sockets are available permitting easy tube replacement and low cost chassis assembly operations.

These tubes have been standardized and registered with RMA. The day of pocket superheterodyne receivers for police patrol, fire-fighting, railroad operation and sport and entertainment reception is here, now. For long life, rugged construction, low assembly and maintenance costs—with user acceptance assured—use Raytheon Standard Sub-Miniature tubes. Technical data sheets available on request.



RAYTHEON
MANUFACTURING COMPANY

Excellence in Electronics

RADIO RECEIVING TUBE DIVISION
Newton, Mass. • New York • Chicago

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"precision made" means
fewer headaches
for you

Ceramic parts that are dimensionally accurate and mechanically strong are "headache eliminators" for your production men. Stupakoff takes special precautions throughout all steps of design and manufacture to see that every item is as nearly perfect as modern precision mass-manufacturing methods can make it. As a result, your production of assemblies is speeded, and you have less waste of labor and materials.

The dependable high quality of Stupakoff ceramics assures complete satisfaction.



Precision grinding of fired ceramic parts assures uniformity.



Electrolimit gauging checks dimensions to the fifth decimal.

STUPAKOFF

CERAMIC AND MANUFACTURING COMPANY • LATROBE, PA.

Export Department, 13 E. 40th St., New York, N.Y. Cable Address ARLAB, all codes.



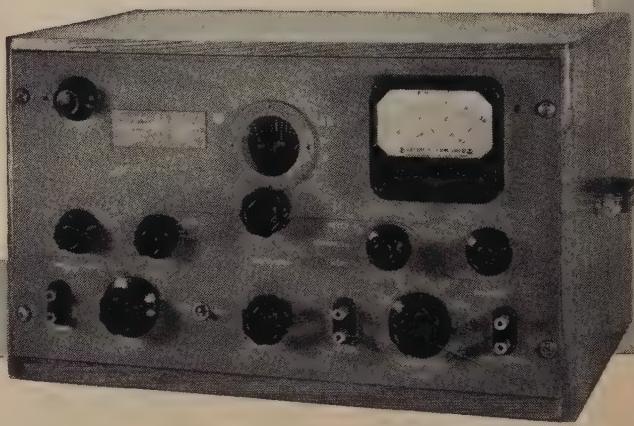
LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

NEW -hp- DISTORTION ANALYZER continuously variable over entire AF spectrum

OUTSTANDING NEW FEATURES

- Covers Audio Spectrum
- Measures Noise as Small as 100 Microvolts
- Linear r-f Detector
- Ball-bearing Frequency Control Dial
- High Order of Accuracy and Stability

MODEL 330B



In the Model 330B Distortion Analyzer, the now-famous Hewlett-Packard resistance-tuned circuit is used in conjunction with an amplifier to provide many new and outstanding advantages. Here is an instrument which will measure "total" distortion at any frequency from 20 cps to 20,000 cps. Thus for the first time an instrument which covers the audio spectrum is available for distortion measurements. The Model 330B will also make noise measurements of voltages as small as 100 microvolts. A linear r-f detector makes it possible to measure these characteristics directly from a modulated r-f carrier. This feature, coupled with the convenience, high sensitivity, accuracy, stability, and light weight which are traditional in all -hp-instruments, make the Model 330B uniquely valuable for broadcast, laboratory, and production measurement.

USES

The flexibility of the Model 330B leads to a wide number of applications.

It may be used to measure the total distortion at any frequency of an audio signal, or of an audio-modulated r-f carrier. It may also be used as a voltmeter for measuring voltage level, power output, amplifier gain, or for any other use for which a high-impedance, wide frequency range, high sensitivity voltmeter is desirable. The frequency selective amplifier can be used as an audio-frequency meter to determine the frequency of an unknown audio signal. The Model 330B may also be used as a high-gain, wide-band, stabilized amplifier, having a maximum gain of 75 db.

This new Model 330B Distortion Analyzer is particularly adapted for use as an all-round measurement device in the broadcast studio and broadcast transmitting room. Speed and ease of operation commend it for laboratory and production testing. Write today for complete data, prices and delivery information on -hp's newest and finest distortion measuring instrument, the 330B Distortion Analyzer.

1156



NEW MODEL 201B RESISTANCE-TUNED AF OSCILLATOR

In FM and other fields where high fidelity is important, this new -hp- Model 201B Audio Frequency Oscillator will meet every requirement for speed, ease of operation, accuracy, and purity of waveform. Outstanding new features include: 3 watts output, distortion less than $\frac{1}{2}$ of 1%, low hum level, new dial with ball-bearing drive, accurate expanded frequency calibration, improved control of output level. Because of its low distortion it is a distinguished companion instrument for the new Model 330B Distortion Analyzer. Write today for complete specifications on this new -hp- Resistance-tuned, Audio Oscillator.

HEWLETT-PACKARD COMPANY

BOX 1156D • STATION A • PALO ALTO, CALIFORNIA



Audio Frequency Oscillators

Noise and Distortion Analyzers

Square Wave Generators

Signal Generators

Wave Analyzers

Frequency Standards

Attenuators

Vacuum Tube Voltmeters

Frequency Meters

Electronic Tachometers

It's Collins!

It's new!

It's ready!

... the Collins 30K—a NEW transmitter for amateur radio—thoroughly engineered for the continuous exacting requirements of "ham" operation. Check this partial list of features against your desires:

5 band operation • 500 watts input on CW • 375 watts input on Phone • Push-to-talk • Clean, sharp keying • Speech clipper • Bandswitching • Fully metered • Break-in operation • Vfo controlled

The high efficiency of the 30K assures a strong signal. In addition, the speech clipper circuit assists in maintaining a high modulation level, with no danger of overmodulation. Speech clipping also improves intelligibility. Brass pounders will proudly note the clean keying at any speed.

The exciter unit, built into a receiver type cabinet, may be placed on the operating desk. A highly accurate and stable variable frequency oscillator, the product of years of research and manufacturing experience, is calibrated directly in frequency. The frequency can be varied considerably without retuning the final.

The attractive appearance of this up-to-the-minute transmitter will improve any "shack." Its smooth, easy operation will please you.

Write today for complete details. Collins Radio Company, Cedar Rapids, Iowa; 11 West 42nd Street, New York 18, N. Y.



The Collins 30K



FOR RESULTS IN AMATEUR RADIO, GET...





more efficient ...in miniature

Flickering firebrands of burning fagots, smoking pine knots and pitch soaked moss lacked the convenience and effectiveness of the modern flash light. It took the same type of imagination, backed by science, to develop efficient miniature mobile lighting as it did to develop miniature Electron Tubes.

Due to their inherent improved characteristics, TUNG-SOL Miniatures are found in high frequency circuits in which the use of the larger type tubes would be impractical. In other circuits TUNG-SOL Miniatures are also more satisfactory. They are more rugged and more resistant to vibration. Because they are smaller, and lighter, TUNG-SOL

Miniatures make possible the production of smaller and lighter equipment. This is the trend of today.

TUNG-SOL Engineers will be glad to help you interpret your tube requirements in terms of Miniatures. TUNG-SOL is a tube manufacturer, not a set builder. The disclosures of your plans you make in consultation will be held in strictest confidence.



ACTUAL SIZE

TUNG - SOL

vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS, INC., NEWARK 4, NEW JERSEY
 Sales Offices: Atlanta • Chicago • Dallas • Denver • Detroit • Los Angeles • New York
 Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors

multiply your **MOVES** with **alliance**

Model RR enclosed split-phase Reversible Motor. Alliance Motors are rated from less than 1-400th up to 1-20th H.P. With or without integral gears.



POWR-PAKT MOTORS

To get more motion—remote control—automatic action—that's the aim of most modern designs!

Alliance miniature Powr-Pakt Motors—light weight, compact, easy to install, grew from the millions of Alliance Phonomotors made for the radio industry.

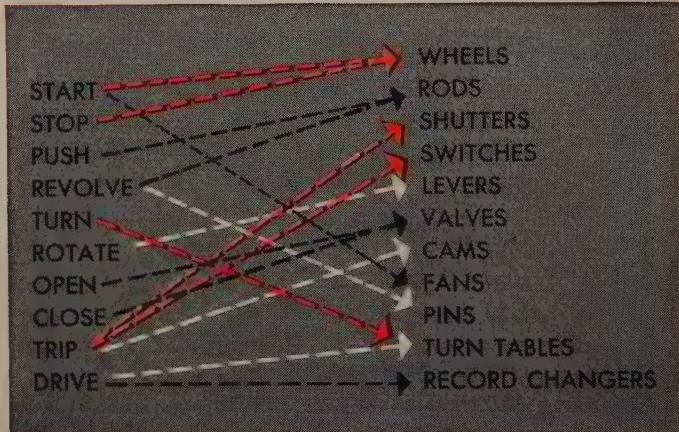
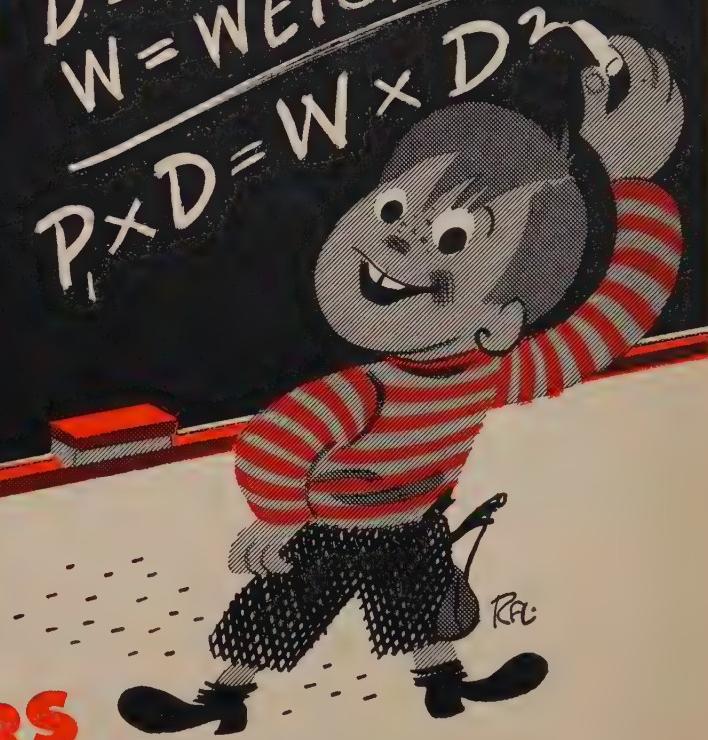
As vital component power links in every electronic, radio and heating control sequence, they'll reduce waste motion, manual effort, and *Multiply Your Moves!*

$$P = \text{POWER}$$

$$D = \text{DISTANCE}$$

$$W = \text{WEIGHT}$$

$$P \times D = W \times D^2$$



WHEN YOU DESIGN—KEEP

alliance

MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO

ALLIANCE TOOL AND MOTOR LTD., TORONTO 14, CANADA

STACKPOLE

MOLDED IRON CORES

STANDARD AND HIGH-FREQUENCY TYPES

A pioneer in Iron Core production, Stackpole can supply practically any desired type from 100 cycles to upward of 175 megacycles and in an infinite variety of shapes, sizes and characteristics. Also available are High-Resistivity Cores showing a resistance of practical infinity; Insulated Cores wherein the screws are kept out of the coil field and "Q" consequently increased; Iron Cores for choke coils; and Side-Molded Iron Cores featuring uniform permeability with respect to linearity. Write for details and samples of any type.

for higher "Q" STACKPOLE SCREW-TYPE MOLDED CORES

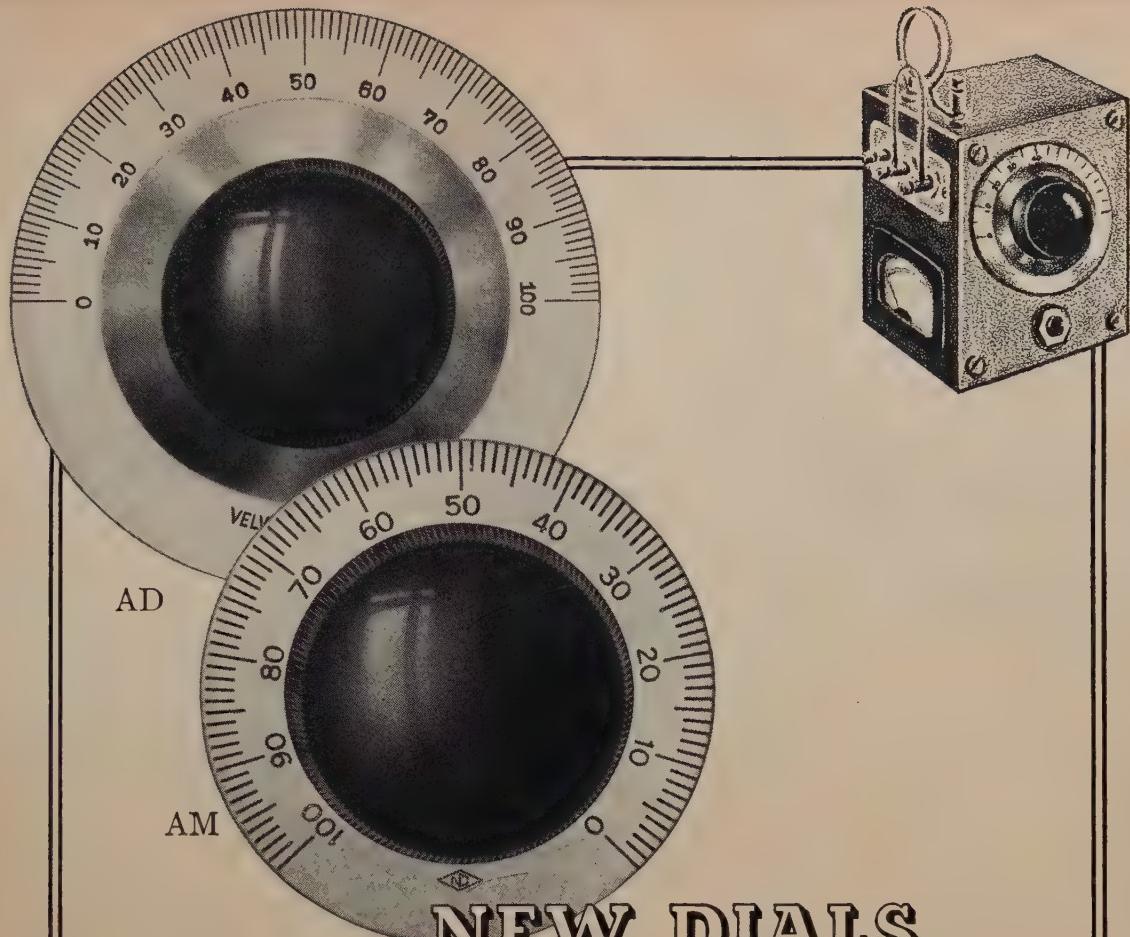
These Stackpole developments are proving highly popular for circuits where small assemblies are the order of the day, and where "Q" must be kept at an absolute minimum. The cores themselves are threaded, thus eliminating the conventional brass core screw. Tubes can be threaded to fit cores if desired. More economical, however, is the use of a wire C-spring clip placed (obtainable from usual sources of supply) in a slot in an unthreaded tube. Stackpole Screw-Type Cores are ideal for the design of I-F and dual I-F Transformers for AM and FM.

IRON SLEEVE TYPES ... for better coils in less space

By use of Stackpole Sleeve Cores, much smaller cans of any material may be used to provide "Q" that is equal to, or better than, that of conventional cores and cans. Thus they facilitate an exceptionally high order of tuning unit efficiency in greatly reduced size. Cans are not always necessary — and, where they are, inexpensive aluminum containers may often be used.

LOOK FOR THE
STACKPOLE MIN-
UTE MAN . . .
your assurance of
the highest in
molded materials
quality.

STACKPOLE CARBON CO., Electronic Components Division, ST. MARYS, PA.



NEW DIALS

Wartime requirements for accurate smooth-working dials resulted in the design of these two new models. Both make use of the time-tested "Velvet Vernier" drive unit which for more than twenty years has been a favorite because of its incomparably smooth action and sensitive control. The Type AM Dial is three inches in diameter and is available with 2, 3, 4, 5 or 6 scale. The four-inch Type AD Dial is made with 2, 3, 4 or 5 scale.

Both are handsome in appearance and moderate in cost.

DIAL SCALES			
Scale	Divisions	Rotation	Direction of Condenser Rotation for increase of dial reading
2	0-100	180°	Counter Clockwise
3	100-0	180°	Clockwise
4	150-0	270°	Clockwise
5	200-0	360°	Clockwise
6	0-150	270°	Counter Clockwise



NATIONAL COMPANY, INC., MALDEN, MASS. U.S.A.



KNIT MONEL MESH Shielding Rings

for h-f electronic applications

HERE'S a war development that may offer an answer to your shielding problems in high-frequency equipment.

It is shielding rings of resilient Monel mesh. They were first used by the U. S. Army Signal Corps.

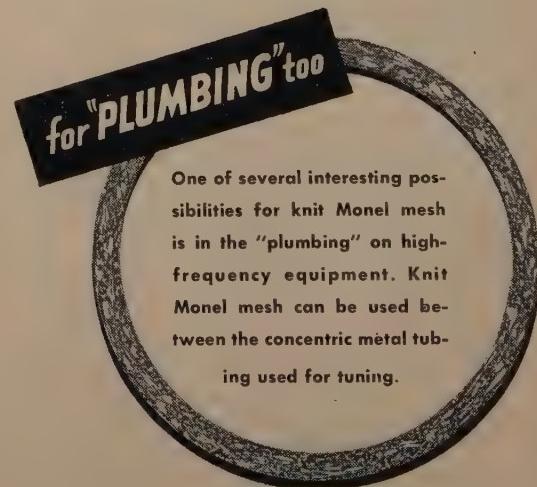
The resiliency of Monel mesh assures continuous contact at all points. And, Monel's corrosion resistance minimizes any loss of over-all conductivity from attack by moisture-laden air or sea water.

When used in place of fabricated sheet metal shields, these rings speed production and assembly . . . reduce space requirements . . . simplify disassembly.

And, where fluid seal attachments are needed, designers find that Monel can be satisfactorily bonded to rubber-like materials.

Most important, Monel mesh shielding rings do a fine job of "frustrating" straying h-f currents. Currents that "want out" have to run around in circles until they crawl back into the box.

Investigate this new shielding method. Knit Monel mesh can be made into rings of all types and sizes to fit individual requirements. For more information write: Metal Textile Corporation, Orange, New Jersey.



THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street, New York 5, N. Y.

get to know all the - **NICKEL**



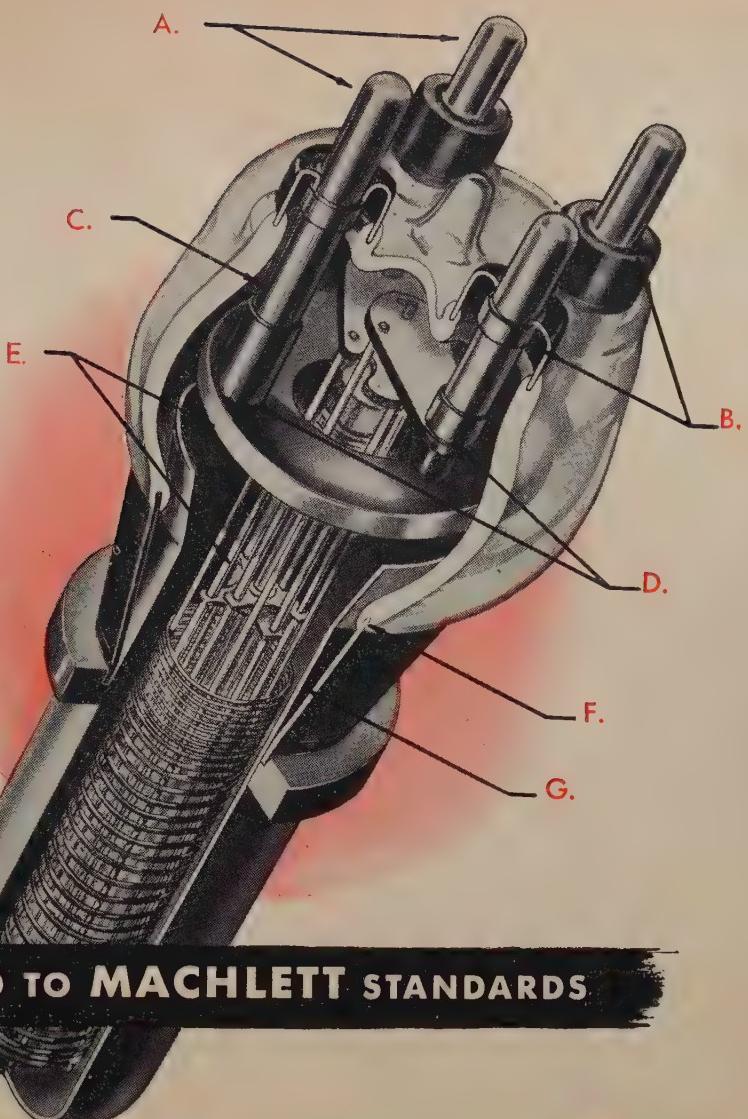
ALLOYS

MONEL* • "K" MONEL* • "R" MONEL* • "KR" MONEL* • "S" MONEL*

INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL* *Reg. U. S. Pat. Off.

Proceedings of the I.R.E. and Waves and Electronics

June, 1946



Sectional view of the ML-889-A, showing features typical of Machlett external anode tube construction.

- A. Gold-plated contact surfaces
- B. Rugged Kovar grid and filament seals
- C. One-piece high-conductivity copper grid and filament support leads
- D. Rigidly-supported grid and filament assemblies
- E. Surgically-clean internal parts
- F. Rugged Kovar plate seal
- G. One-piece anode and shield

REDESIGNED TO MACHLETT STANDARDS

For better performance and longer life! **ML-892**

HERE is another outstanding example of Machlett's ability to apply to the design and manufacture of high-power triodes its unique skills acquired in the manufacture of X-ray tubes. Remember, those skills were developed through almost 50 years of X-ray tube production—and an X-ray tube presents manufacturing problems of the greatest severity in the electron-tube art. Machlett's ability to solve those problems has resulted in making it the largest producer of X-ray tubes in the world. Note these features of the ML-892:

1. Heavy Kovar sections for grid and plate seals, instead of feather-edge copper. Result—greatly increased mechanical strength.
2. Grid assembly supported by heavy Kovar cup, for strength and stable inter-element spacing.
3. Filament assembly greatly strengthened to increase life and preserve correct spacing.
4. All internal parts processed by special

Machlett techniques which prevent contamination by foreign particles, assuring permanent outgassing.

5. Tube pumped by unique Machlett continuous, straight-line, high-voltage process, assuring same high standards maintained in Machlett high-voltage X-ray tubes.

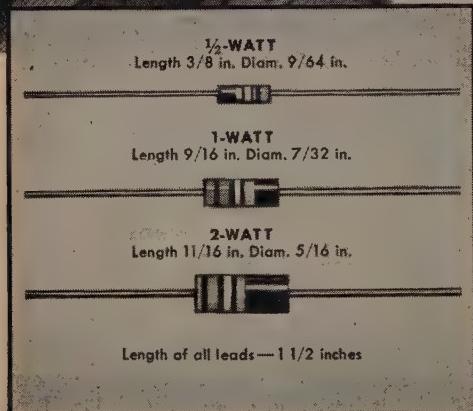
* * *

For complete details of this greatly improved tube, write Machlett Laboratories, Inc., Springdale, Connecticut.

GENERAL CHARACTERISTICS	
ML-892	ML-892-R
Filament Voltage	22
Filament Current	60
Amplification Factor	50
Maximum frequency for full power	1.6
Capacity grid to plate	27
Capacity grid to filament	18
Capacity plate to filament	2
Cooling	Water 3 to 8 G.P.M.
	Air 400-700 C.F.M.

MACHLETT

APPLIES TO RADIO AND INDUSTRIAL USES
ITS **49** YEARS OF ELECTRON TUBE EXPERIENCE



"These fixed resistors pack the greatest wattage capacity for their size"

Bradleyunit solid-molded, fixed resistors are not rated on the basis of the conventional 40 C ambient temperature . . . instead they are rated at 70 C ambient temperature.

Bradleyunits . . . in 1/2-watt, 1-watt, and 2-watt ratings . . . will operate at full rating for 1000 hours in an ambient temperature of 70 C, with a resistance change of less than 5 per cent. They pass salt water immersion tests without wax impregnation. All three sizes are available in standard R.M.A. values from 10 ohms to 22.0 megohms, inclusive.

Such "extra" performance improves the dependability of your electronic equipment. Specify Bradleyunit resistors . . . and you add "extra" quality to your products.

Allen-Bradley Company, 114 W. Greenfield Ave.,
Milwaukee 4, Wisconsin.



Type J Bradleyometers are the only continuously adjustable, solid-molded resistors having a 2-watt rating with a generous safety factor. Any resistance-rotation curve is available.



ALLEN-BRADLEY

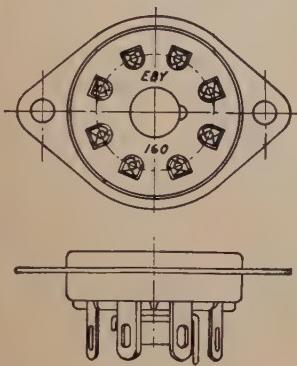
FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY

NEW EBY SOCKETS

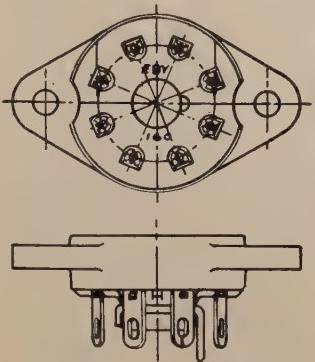
Lock-In, Octal, and Non-Microphonic

LOCK-IN
(Glass Bonded Mica)



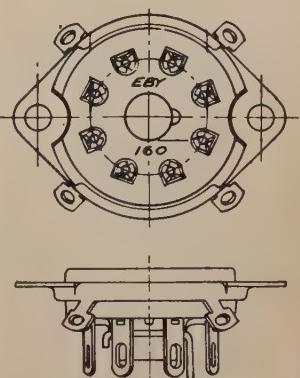
Chassis Hole— $1\frac{1}{16}$ " dia.
Mounting Centers— $1\frac{5}{16}$ "
Mounting—Top or Bottom

LOCK-IN



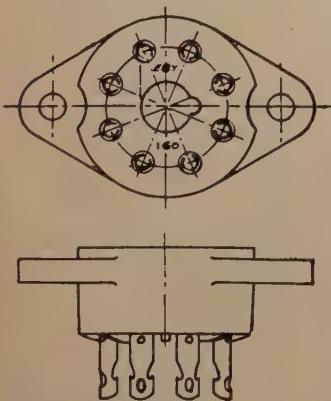
Chassis Hole— $1\frac{1}{16}$ " dia.
Mounting Centers— $1\frac{5}{16}$ "
Mounting—Top or Bottom

LOCK-IN



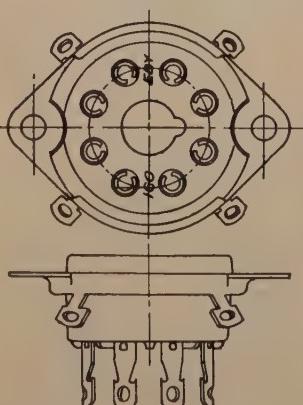
Chassis Hole— $1\frac{1}{16}$ " dia.
Mounting Centers— $1\frac{5}{16}$ "
Mounting—Top or Bottom
With or without Grounding Lugs

OCTAL



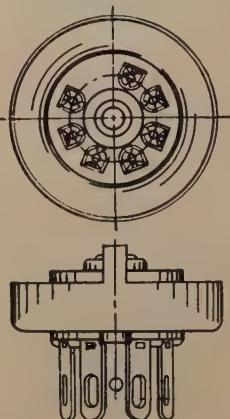
Chassis Hole— $1\frac{1}{16}$ " dia.
Mounting Centers— $1\frac{5}{16}$ "
Mounting—Top or Bottom

OCTAL



Chassis Hole—1" dia.
Mounting Centers— $1\frac{5}{16}$ "
Mounting—Top or Bottom
With or without Grounding Lugs

NON-MICROPHONIC
(Miniature)



Chassis Hole— $\frac{31}{32}$ " dia.
Mounting Centers— $\frac{7}{8}$ "
Mounting—Top or Bottom

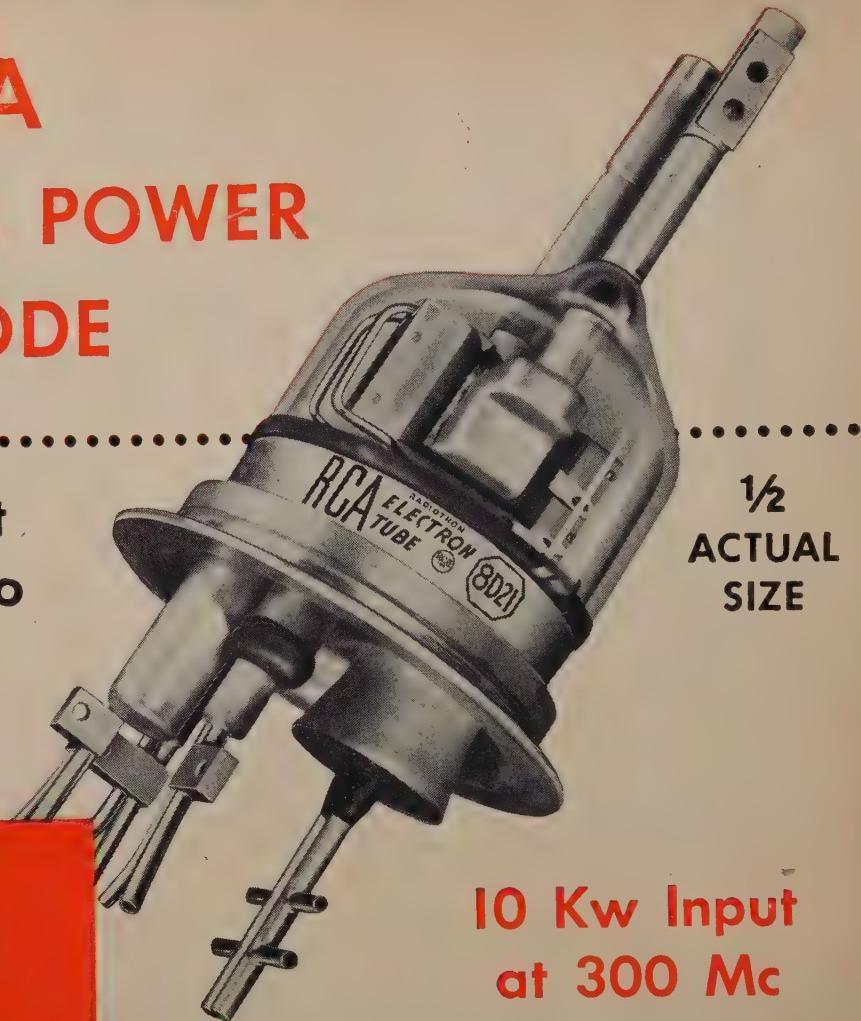
Write today for
complete details . . .

HUGH H.
E BY
INCORPORATED
18 W. CHELTEN BLDG.
PHILA., PENNA.

RCA

8D21 TWIN POWER TETRODE

An important
contribution to
Television
Broadcasting



**10 Kw Input
at 300 Mc**

Unusual construction is indicated by this view of the header with filament, grid #1 and grid #2 in position. Precision cast and machined electrodes are connected to water ducts for internal cooling.

THE RCA-8D21 Push-Pull Power Tetrode for television and FM broadcasting service is a radical departure from previous transmitting tube designs in that high-power capability at very high frequencies is achieved through the use of an exceedingly compact, high-current-density structure in which *all electrodes are water-cooled close to the active electrode areas* . . . resulting in a concentration of power in a tube only 12 inches in over-all height and 5½ inches in diameter!

The structure features a thorium-coated, multi-strand filament; low inter-electrode capacitances; excellent internal shielding between input and output circuits; internal neutralization of the small feedback capaci-

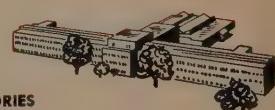
tance to eliminate need for external neutralization; internal by-passing of screen to filament to maintain the r-f potential of the screen at ground potential; and relatively short internal leads with consequent low inductances.

Because of electron optical principles incorporated in its design, the 8D21 has high power sensitivity and thus its driving-power requirements are low.

When used as a Class C, grid-modulated, push-pull, r-f amplifier in television service, the 8D21 has a maximum plate-voltage rating of 6000 volts, a maximum total plate input of 10,000 watts, and a total plate dissipation of 6000 watts. It may be operated with

maximum rated input as high as 300 Mc.

A technical bulletin on the RCA-8D21 is available on request. RCA Tube Application Engineers will be glad to work with you in adapting this or any other RCA tube type to your equipment designs. Address RCA, Commercial Engineering Department, Section D-18F, Harrison, N. J.



PRINCETON
LABORATORIES

THE FOUNTAINHEAD OF
MODERN TUBE DEVELOPMENT IS RCA.

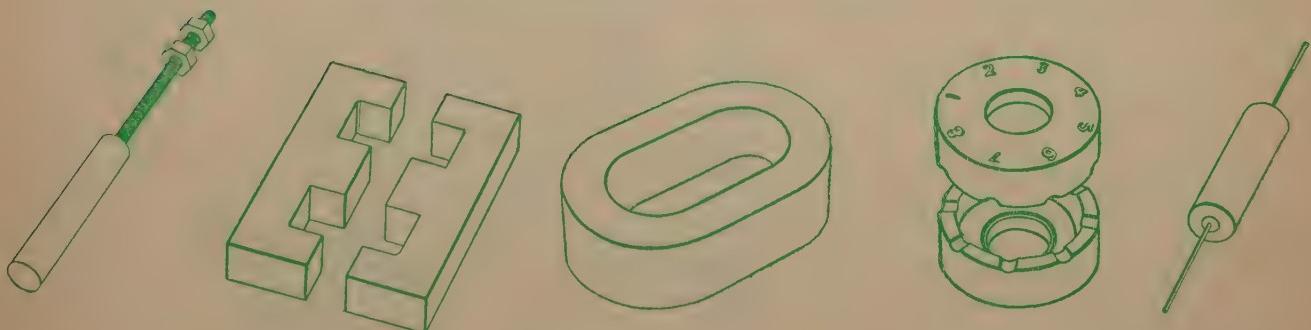
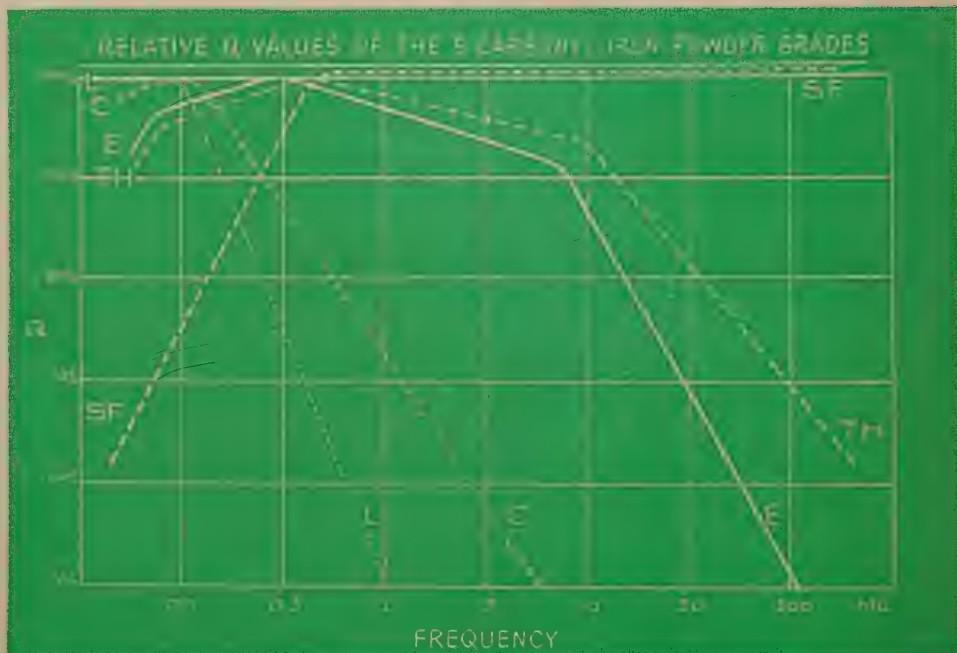


TUBE DEPARTMENT

RADIO CORPORATION of AMERICA
HARRISON, N. J.

**Diameters and Chemical Composition
of the 5 Carbonyl Iron Powder Grades**

Carbonyl Iron Grade	Weight-Average Diameter Microns	Total Fe Content %	Total Carbon Content %
L	20	99.7-99.9	0.005-0.03
C	10	99.5-99.8	0.03 -0.12
E	8	97.9-98.3	0.65 -0.80
TH	5	98.1-98.5	0.5 -0.6
SF	3	98.0-98.3	0.5 -0.6



"L" Type Powder used in cores for permeability tuning.

"C" Type Powder for E-cores in filter coils.

For antenna coils, "E" Type Powder used in cores.

"TH" Type Powder is employed for cup shields in coils.

One use of "SF" Type Powder is in high frequency choke cores (with sealed-in leads).

G.A.F. CARBONYL IRON POWDERS

NOW!

FM



PARTIAL TECHNICAL DATA

- Engineered for FM broadcast stations operating on an 88 to 108 mc. carrier.
- Loops are approximately 4½ feet square.
- Coaxially-fed loops concentrate radiated power in every direction of the horizontal plane.
- 8 loops are spaced 9 feet 3 inches apart on square supporting tower.
- Lattice-type steel supporting tower is two-feet square, and 74 feet high. It mounts a standard aviation safety beacon on top.
- Pyramidal, bridge-construction steel base optional to height desired.
- Designed to handle 10KW, 20KW and 50KW transmitters with effective radiated power outputs of 90KW, 180KW and 450KW respectively.

WTMJ—The Milwaukee Journal Station, Milwaukee, Wis., ordered this new Federal 8 Square-Loop Antenna with a 540 foot self-supporting tower, for immediate delivery.

Federal

Export Distributor:
International Standard Electric Corporation

skilled springmakers . . .
AND practical,
experienced engineers,
SPECIALISTS
in spring design
and manufacture

At Accurate



It takes people to make springs. Ours are specialized, highly trained, long-experienced people—well qualified to give you the finest in spring craftsmanship.

Q Our engineers too, are an important reason why you'll like Accurate Spring Service. They're old hands at spring-making . . . they've developed manufacturing systems and procedures that enable us to handle your jobs with the greatest speed and efficiency. These Accurate engineers are at your service on spring design problems. You will benefit from their practical assistance in designing exactly the right spring for your application.

Q Why not try Accurate on your next job.

Send for your copy of the new Accurate Spring Handbook. It's full of data and formulae which you will find useful. No obligation of course.

ACCURATE SPRING MFG. CO.
3835 W. Lake Street Chicago 24, Illinois

SPRINGS • WIREFORMS • STAMPINGS

*Accurate
Springs*

A stylized graphic featuring the words "Accurate" and "Springs" in a flowing script font. A coiled spring is integrated into the letter "a" of "Accurate" and the letter "s" of "Springs". A small drawing of a pen or pencil is positioned above the "a". The entire logo is set against a red horizontal bar.

POSITIONS OPEN

The following positions of interest to I.R.E. members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No.

The Institute reserves the right to refuse any announcement without giving a reason for the refusal.

PROCEEDINGS of the I.R.E. 330 West 42nd Street, New York 18, N.Y.

PHYSICISTS

Two Physicists, M.S. or Ph.D. (experience preferred) for long term project in microwave research and development. For details write Box 417.

RADIO INSTRUCTORS

Receiver servicing experience. Degree preferred. \$3600 to start; \$4200 after 4 months. Work in the heart of the radio industry. Write Raleigh G. Dougherty, c/o New York Technical Institute of New Jersey, 158 Market St., Newark 2, N.J.

PRODUCTION EXECUTIVES

Two executives: Production Manager also Head Production Control Department with several years experience in electronic equipment manufacturing and assembly. Salary \$5000 to \$8000. Write for interview describing background and experience especially peacetime production responsibilities before the war. Box 418.

EXECUTIVE ELECTRONICS ENGINEER

At once by Connecticut manufacturer who is fast moving into the realms of larger business—must be an engineering school graduate; experienced in radio, electronics, and electricity; must have administrative experience and stature; must have product and production evaluation knowledge; must get along with an energetic, independent organization. Write all details in first letter; salary expected; recent picture. Box No. 415.

FACTORY ENGINEER

We have openings in our Factory Engineering Division for two outstanding men. Experienced background of at least five years engineering work on factory problems relating to receiving tube manufacture required. Engineering degree would be helpful, but primary requirements of the positions are the experience and ability to successfully solve the everyday problems encountered in the manufacture of receiving tubes. Apply by letter to Personnel Department, National Union Radio Corporation, Lansdale, Pa.

ENGINEERS

TELEVISION. Experienced television receiver senior engineer.

RADIO. Experienced home set senior engineer.

Both positions are permanent and offer excellent opportunity and pay. United States Television Manufacturing Corp., 3 West 61st Street, New York 23, N.Y.

WANTED: TOP FLIGHT DESIGN ENGINEER FOR SENIOR ADMINISTRATIVE POST

Must have substantial prior experience in carrying the full responsibility of an engineering department that has a long successful record in producing complete and varied lines of radio transmitters for commercial services, including FM and AM Broadcasting, Point-to-Point Communication, Aviation Marine and Police. The man we are seeking must be a graduate Electrical Engineer with a full, all-embracing theoretical knowledge, combined with extensive practical application. His experience should include first hand knowledge of important recent FM and AM and Microwave developments in the communication field.

Because the man selected for this important post must assume great responsibility, his compensation will consist of a high bracket salary, plus a production bonus incentive. This arrangement will afford him a most unusual opportunity to earn a very substantial income, directly in proportion to his demonstrated ability.

Our company (located in New York City) has been established for many years and enjoys a world-wide reputation for high standard, custom-built communication equipment. Our war record is unexcelled and our post-war expansion program which is already under way, forecasts an important position in the forefront of the communication industry.

This is a job for a man who has reached a ceiling in his present position and must make a change to increase his income, or an assistant chief engineer who has not been permitted the full employment of his capabilities. Write to us, telling enough about your qualifications and past experience to warrant an interview. All communications will be held in strictest confidence. Our organization knows about this advertisement. Address your letter to the attention of the President,

BOX 416

THE INSTITUTE OF RADIO ENGINEERS
330 WEST 42ND STREET, NEW YORK 18, N.Y.

★ ★ ★ Positions Wanted By Armed Forces Veterans

In order to give a reasonably equal opportunity to all applicants, and to avoid overcrowding of the corresponding column, the following rules have been adopted:

The Institute publishes free of charge notices of positions wanted by I.R.E. members who are now in the Service or have received an honorable discharge within a period of one year. Such notices should not have more than five lines. They may be inserted only after a lapse of one month or more following a previous insertion, and the maximum number of insertions is three per year. The Institute necessarily reserves the right to decline any announcement without assignment of reason.

JUNIOR ENGINEER

BS in EE, broadcast license since 1940, technician. Desire position with station or as assistant in design or manufacture. Age 24. J. M. McClamrock, 7515 E. Burnside St., Portland, Ore.

AAF ELECTRONIC OFFICER

AAF Electronic Officer with good experience in installation and operation of Loran transmitters or receivers. Experienced with all types of control circuits. Box 15W.

ENGINEER

BEE. UHF. Age 22. Some experience in research and design of test equipment.

Navy work in radar and communication. Desires research or engineering in electronics near NYC. Available August. Box 16W.

RADIO ENGINEER

BS 1941. Courses at C.C.N.Y., N.Y.U., L.I.U., B'klyn Polytech., Yale, Harvard, and M.I.T. Experience testing, research and teaching. Former Radar countermeasures officer. Desiring position New York area. Box 17W.

ENGINEER

M.I.T. trained radar officer, BS physical chemistry Rutgers 1941, photochemical research, electronic teaching, vacuum tube manufacturing experience. Seeks development work electronics or physical chemistry. Box 18W.

RADIO ENGINEER

BS in EE. Three years development electronic equipment and systems. Four years research and development in RF and antenna field both VHF and microwave. Now holding responsible technical position. Available July. Box 19W.

RADAR-COMMUNICATIONS ENGINEER

EE graduate, 25, with Navy officer training at Princeton and M.I.T. in electronics plus duty at NRL. 1½ years experience as radar instructor. First class radio telephone license held. Desires position in June. Box 20W.

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1. Overall frequency range—540 kilocycles to 32 megacycles in 4 bands.
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8. Maximum audio output—1.6 watts.
9. Internal PM dynamic speaker mounted in top.
10. Controls arranged for maximum ease of operation.
11. 105-125 volt AC/DC operation. Resistor line cord for 210-250 volt operation available.
12. Speaker/phones switch.

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OPERATING DATA: The Model S-38 is designed to operate on 105-125 volts AC or DC. A special external resistance line cord can be supplied for operation on 210 to 250 volts AC or DC. Power consumption on 117 volts is 29 watts.

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(Continued from page 50A)

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(Continued on page 54A)



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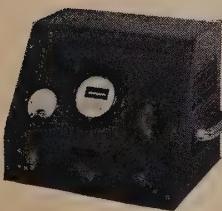
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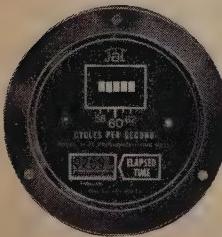
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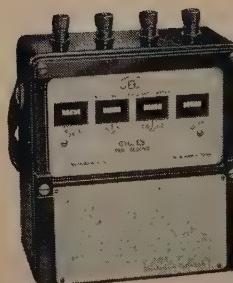
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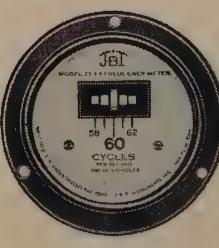
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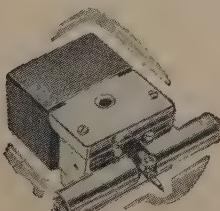
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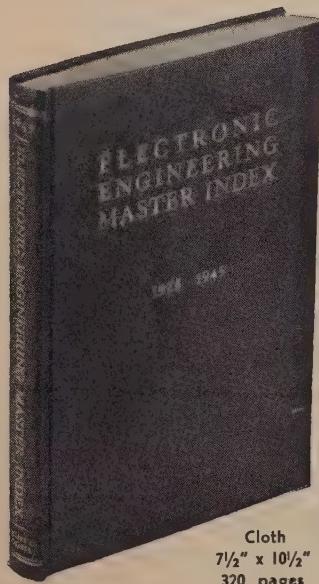
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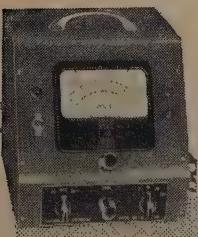
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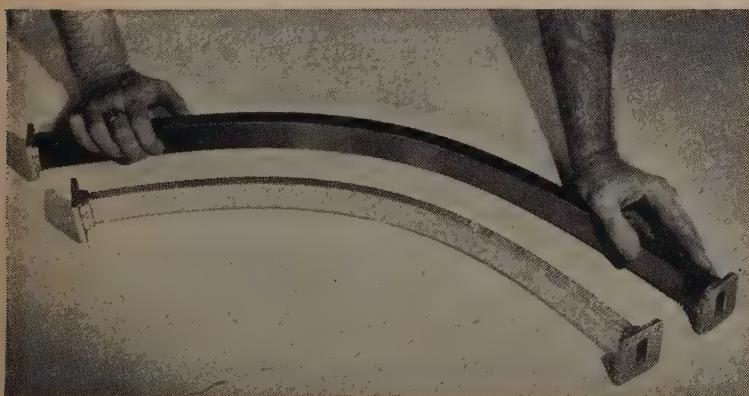


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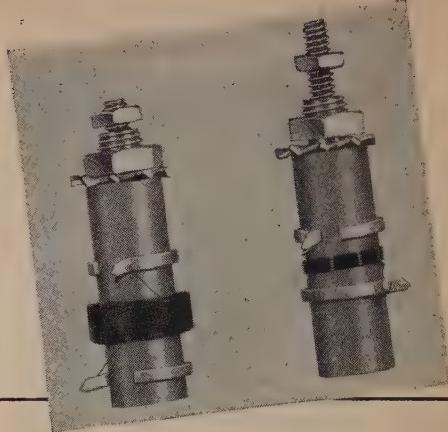
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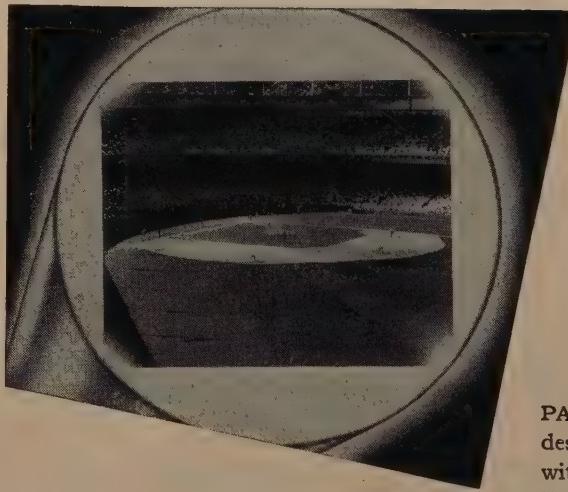


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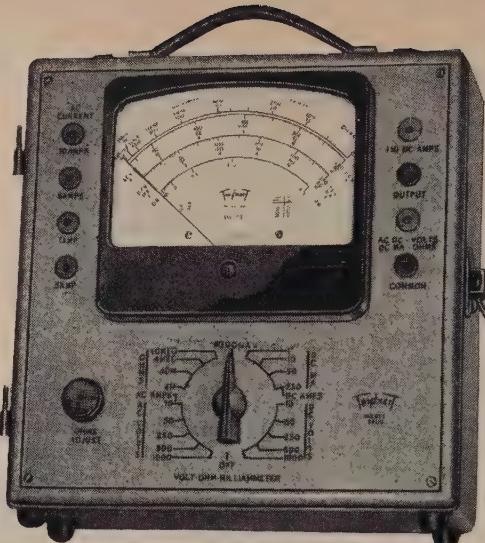
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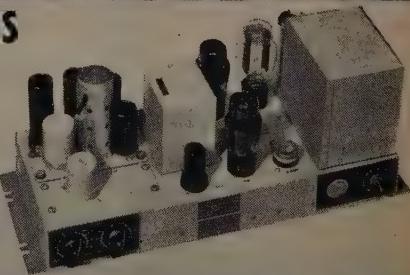
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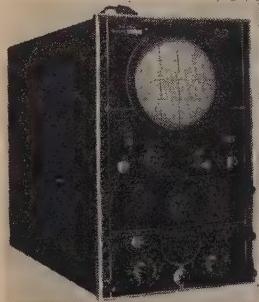
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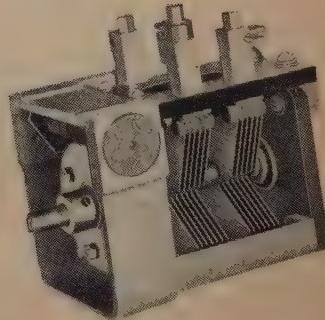
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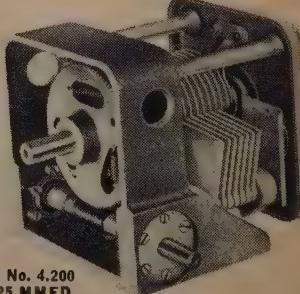
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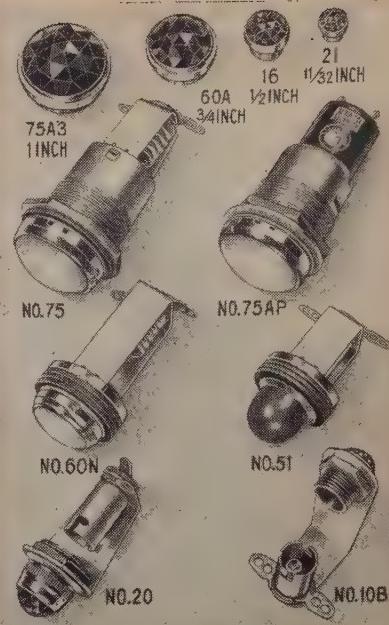
New Fields For Tubes

(Continued from page 68A)

Special-type tubes, including the phototube group, found many important military applications during the war, and production and sales of such tubes rose to a peak about seven times their 1939 levels. Their potential field of peacetime applications is almost limitless, since electron tubes are now performing all of the functions of the five senses; there literally is no industry which cannot employ electronic devices to advantage in its operations.

It is obvious the greatest peacetime problem is that of providing immediate utilization of war-expanded manufacturing facilities for power, cathode-ray, and special-type tubes. Although a number of years probably will elapse before production of such tubes will again reach wartime peaks, it is confidently expected that peacetime demand for these tubes will ultimately exceed peak wartime production. Television, for example, offers early promise of reaching that goal on cathode-ray tubes.

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 - () B. Dry "B".
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- () 12. CABLES:
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 - () D. Shielded.
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 - () D. Oil Filled.
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 - () C. Temperature-Frequency Compensating.
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 - () F. Vacuum.
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 - () B. Ground Mica.
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 - () D. Sheets.
- () 16. CHASSIS.
- () 17. CHOKE COILS:
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 - () B. Power.
 - () C. Radio Frequency.*Coil Forms, see Ceramics.*
- () 18. COILS.
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 - () C. Vibrator.
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 () D. Wave Guides.
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 () C. Industrial Types.
 () D. Klystrons & Magnetrons.
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 () J. Voltage Regulator.
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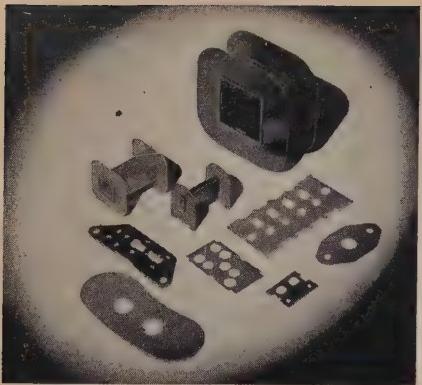
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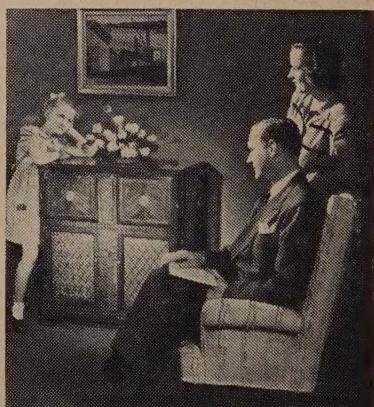
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NEW FILAMENT STRUCTURE!

Physically the new Eimac 3-250A triode is interchangeable with the old Eimac 250T. The new elements result in better performance and even longer life in a tube that has long been famous for its long life and stamina. This new tube is available in both low mu [3-250A2] and high mu [3-250A4] tube versions.

Its outstanding performance characteristics are exemplified by its low driving power requirements. For example, in Class C telegraphy, with 3000 plate volts on a single tube, the Eimac 3-250A2 [low mu] will deliver 750 watts output with only 29 watts [approx.] of driving power. [See chart.]

You can depend upon Eimac year in and year out for leadership in vacuum tube developments.* That's one reason why Eimac tubes are today, and have been for years, first choice of leading electronic engineers throughout the world.

*Ask your dealer to give you a copy of "Eimac Electronic Products" just off the press. Or write direct.

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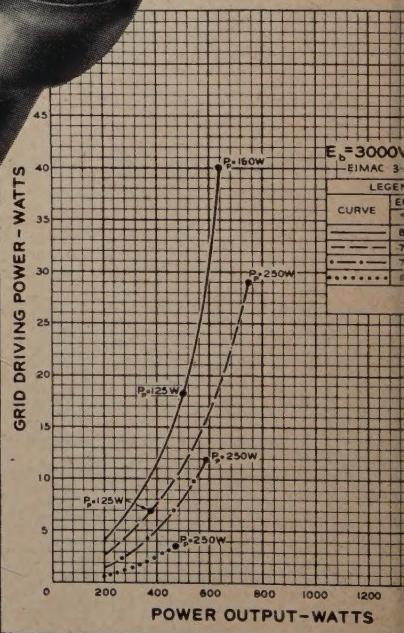
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EIM
3-25



ELECTRICAL CHARACTERISTICS

Filament: Thoriated tungsten	3-250A2	3-250A4
Voltage	5.0 volts	5.0 volt
Current	10.5 amperes	10.5 amperes
Amplification Factor (Average)	14	37
Direct Interelectrode Capacitances (Average)		
Grid-Plate	3.1 uuf	2.9 uuf
Grid-Filament	3.7 uuf	5.0 uuf
Plate-Filament	0.7 uuf	0.7 uuf

